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of the

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Volume 88

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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 88, No. 1, pp. 1–10 JANUARY, 1961

ABBREVIATIONS OF TITLES OF SERIALS CITED BY BOTANISTS. SUPPLEMENT 1*

Lazella Schwarten and Harold William Rickett
The Libraries
Arnold Arboretum and Gray Herbarium
and
The New York Botanical Garden

The demand for separate copies of our list of abbreviations has indicated that botanists find it useful. Some of our friends have suggested that the list be enlarged by the inclusion of additional titles. While it should be clear that anyone can make his own abbreviations by our method (see the introduction to our paper*), it may be helpful to supplement the original list. It is useful to have not only standard abbreviations but also exact titles and provenance. This is especially true of departmental publications of South American governments and of some older serials that have been "dead" for many years; such titles are available only in the larger libraries, and are often confused.

Some of our colleagues have called our attention to errors in the list. We offer no apologies for errors, which are almost impossible to avoid in a compilation of this character; we are grateful for help in recognizing them, and we include herewith necessary corrections.

Note on the Citation of Parts of Volumes. When it is necessary, a part of a volume can be indicated by a number in parenthesis or superscript: Univ. Iowa Stud. Nat. Hist. **20**(2): 1–102 or **20**^{2}: 1–102. This is generally a needless expense and may increase the chance of typographical error; it is necessary only when parts are separately paged.

The use of parentheses in this way provides also for the citation of special parts, departments, supplements, etc.: Bot. Jahrb. **3** (Beibl.1): 1–3. Linnaea **3** (Lit.-Ber.): 1–188. Jour. Bot. London **46** (Suppl.): 1–110.

CORRECTIONS

Ann. N. Y. Acad.—Annals of the New York Academy of Sciences. [Superseded Ann. Lyc. Nat. Hist. N. Y.]

Contr. U. S. Natl. Herb.—Contributions from the United States National Herbarium. [United States National Museum, Smithsonian Institution.]

Fl. Males. Bull.—Flora Malesiana Bulletin. [Flora Malesiana Foundation, Leyden.]

Gard. Jour. N. Y. Bot. Gard.—The Garden Journal. [The New York Botanical Garden.]

Hooker's Ic. Pl. V.—Hooker's Icones Plantarum or figures . . .

* A few separates of our list of abbreviations (Bull. Torrey Club **85**: 277–300) are still available. Those who already have these may obtain a copy of this supplement by sending 15 cents (or $1.25 for 10) to either author.

[The BULLETIN for November–December 1960 (**87**: 375–448) was issued December 15, 1960.]

Inst. Paran. Fl.—Instituto Paranaense de Botânica. [Série] Flora do Paraná. [Curitiba.]

Jour. Bot. London—The Journal of Botany, British and Foreign. [London. Not to be confused with London Jour. Bot.]

Philip. Jour. Sci. Bot.—The Philippine Journal of Science. Section C. Botany. [Philippine Islands. Bureau of Science.]

Revista Univ. Nac. Cuzco—Revista Universitaria. [Universidad Nacional de Cuzco.]

U. S. Natl. Mus. Rep.—The United States National Museum. Annual Report. [Smithsonian Institution.]

ABBREVIATIONS AND TITLES

Abh. Akad. Berlin Physik—Abhandlungen der (Königlichen Preussischen) Akademie der Wissenschaften (zu Berlin). Physikalisch(e)(-Mathematische) Klasse.

Abh. Akad. München—Abhandlungen der Mathematisch-physikalisch Classe der Königlich Bayerischen Akademie der Wissenschaften. [Munich.]

Abh. Böhm. Ges. Wiss.—Abhandlungen der Königlich Böhmischen Gesellschaft der Wissenschaften.

Abh. Naturw. Ver. Hamburg—Abhandlungen aus dem Gebiete der Naturwissenschaften herausgegeben von dem Naturwissenschaftlichen Verein in Hamburg. [United with its "Verhandlungen" to form its "Abhandlungen und Verhandlungen."]

Acad. Theod.-Palat. Acta—Academia Electoralis Scientiarvm et Elegantiorvm Literarvm Theodoro-palatina. Historia et Commentationes. [Mannheim. Also entitled "Academia Theodoro-palatina. Acta."]

Act. Soc. Hist. Nat. Paris—Actes de la Société d'Histoire Naturelle de Paris. [One vol., 1792.]

Acta Acad. Mogunt. Erfurt—Acta Academiae Electoralis Moguntinae Scientiarum quae Erfurti est.

Acta Acad. Petrop.—Acta Academiae Scientiarum Imperialis Petropolitanae.

Acta Biol. Acad. Hungar.—Acta Biologica Academiae Scientiarum Hungaricae. [Magyar Tudományos Akadémia.]

Acta Bot. Sinica—Acta Botanica Sinica. [Botanical Society of China.]

Acta Helvet.—Acta Helvetica, physico-mathematico-botanico-medica. [Basel, 1751–1777.]

Acta Horti Petrop.—Acta Horti Petropolitani. [St. Petersburg. Imperatorskii Botanicheskii Sad. Trudy.]

Acta Phytotax. Sinica—Acta Phytotaxonomica Sinica. [Botanical Institute of Academia Sinica.]

Acta Sci. Sinica—Acta Scientia Sinica. [Academia Sinica.]

Adansonia—Adansonia. Recueil périodique d'observations botaniques. [Paris, 1863–1879.]

Allg. Gartenzeit.—Allgemeine Gartenzeitung. [Continued as "Berliner Allgemeine Gartenzeitung."]

Am. Mon. Mag. Crit. Rev.—The American Monthly Magazine and Critical Review. [New York, 1817–1819.]

Anal. Ci. Nat.—Anales de Ciencias Naturales. [Madrid, 1799–1804. Vols. 1, 2 as "Anales de Historia Natural."]

Ann. Bot. Roma—Annali di Botanica. [Istituto Botanica, Roma.]

Ann. Bot. Konig & Sims—Annals of Botany. [ed. by Charles Dietrich Eberhard Konig and John Sims; London, 1804–1806.]

Ann. Lyc. Nat. Hist. N. Y.—Annals of the Lyceum of Natural History of New York. [Continued as Ann. N. Y. Acad.]

Ann. Mag. Nat. Hist.—The Annals and Magazine of Natural History; or magazine of zoology, botany, and geology; being a continuation of the 'Magazine of Zoology and Botany' and Sir W. J. Hooker's 'Botanical Companion.' [London. Vols. 1–5 as "Annals of Natural History."]

Ann. Mus. Hist. Nat. Paris—Annales du Muséum (National) d'Histoire Naturelle, [Paris.]

Ann. Mus. Lugd.-Bat.—Annales Musei Botanici Lugduno-Batavi. [1863–1869.]

Ann. Soc. Bot. Lyon—Annales de la Société Botanique de Lyon.

Ann. Wetter. Ges. Naturk.—Annalen der Wetterauischen Gesellschaft für die Gesammte Naturkunde.

Ann. Wiener Mus.—Annalen des Wiener Museums der Naturgeschichte.

Annu. Ist. Bot. Roma—Annuario del R. Istituto Botanico di Roma. [Superseded by Ann. Bot. Roma.]

Arbeit. Bot. Gard. Breslau—Arbeiten aus dem Königlichen Botanischen Garten zu Breslau.

Arch. Bot. Guillemin—Archives de Botanique. [ed. by Jean Baptiste Antoine Guillemin; 1833, 1834.]

Arch. Bot. Paris—Archives de Botanique ou recueil mensuel de mémoires originaux, d'extraits et analyses bibliographiques, d'annonces et d'avis divers concernant cette science; . . . [1833, 1834. Superseded by Ann. Sci. Nat. Bot.]

Arch. Bot. Nord Fr.—Archives Botaniques du Nord de la France. Revue botanique mensuelle. [Lille; Paris.]

Arch. Bot. Römer—Archiv für die Botanik. [ed. by Johann Jakob Römer; Leipzig, 1796–1805.]

Arch. Mus. Hist. Nat. Paris—Archives du Muséum d'Histoire Naturelle, publiées par les professeurs-administrateurs de cet établissement. [Paris. Continuation of "Nouvelles Annales du Muséum . . . "; continued as "Nouvelles Archives . . ."]

Arnold Arb. Bull. Pop. Inf.—Arnold Arboretum, Harvard University. Bulletin of Popular Information. [4 series: continued as "Arnoldia."]

Arnoldia—Arnoldia. A continuation of the Bulletin of Popular Information. [Arnold Arboretum, Harvard University.]

Asiat. Res.—Asiatick Researches: or Transactions of the Society, instituted in Bengal, for enquiring into the History and Antiquities, the Arts, Sciences, and Literature, of Asia. [Calcutta.]

Atl. Jour.—Atlantic Journal, and friend of knowledge. [Philadelphia. 1832, 1833. Published and nearly all written by Rafinesque.]

Beitr. Biol. Pfl.—Beiträge zur Biologie der Pflanzen. [Breslau.]

Beitr. Pflanzenk. Russ. Reich.—Beiträge zur Pflanzenkunde des Russischen Reiches. [Title also in Russian. Kaiserliche Academie der Wissenschaften, St. Petersburg.]

Bibl. Genève—Bibliothèque Universelle de Genève. [Continuation of "Bibliothèque Universelle des Sciences, Belles-Lettres et Arts."]

Biltmore Bot. Stud.—Biltmore Botanical Studies. A journal of botany embracing papers by the director and associates of the Biltmore [North Carolina] Herbarium.

Biol. Centralbl.—Biologisches Centralblatt. [Erlangen; Leipzig.]

Bol. Inst. Hist. Nat. Paraná Bot.—Boletim do Instituto de História Natural. Botânica. [Curitiba, Paraná, Brazil.]

Bol. Mus. Emilio Goeldi—Boletim do Museu Paraense Emilio Goeldi. [Belém. The title of vols. 1–3 was "Boletim do Museu Paraense de Historia Natural e Ethnographia." With vol. 4 (1906) it became "Boletim do Museu Goeldi (Museu Paraense) de Historia . . . " Apparently superseded by Bol. Mus. Emilio Goeldi II. Bot.]

Bol. Mus. Emilio Goeldi II. Bot.—[Conselho Nacional de Pesquisas. Instituto Nacional de Pesquisas da Amazônia.] Boletim do Museu Paraense Emilio Goeldi. Nova Série. [Belém. "Botânica" appears in heading of no. 1.]

Bonplandia—Bonplandia. Zeitschrift für die gesammte Botanik. Officielles Organ der K. L–C. Akademie der Naturforscher.

Bot. Centralbl.—Botanisches Centralblatt. Referirendes Organ für das Gesammtgebiet der Botanik des In- and Auslandes. [Kassel; Jena.]

Bot. Exch. Club Rep.—The Botanical Exchange Club and Society of the British Isles. Report.

Bot. Jahresb.—[Just's] Botanischer Jahresbericht. Systematisch geordnetes Repertorium der botanischen Literatur aller Länder. [Berlin; Leipzig.]

Bot. Misc. Hooker—Botanical Miscellany; containing figures and descriptions . . . with occasional botanical notices and information. By William Jackson Hooker. [London, 1830–1833. Continued as Jour. Bot. Hooker.]

Bot. Reg.—Edward's Botanical Register: or ornamental flower garden and shrubbery: . . . Continued by John Lindley, . . . [London. Vols. 1–14 as "The Botanical Register . . . The designs by Sydenham Edwards, . . ."]

Bot. Repos.—Botanist's Repository for new and rare plants. [London. By Henry C. Andrews.]

Bot. Zhur. Kiev—Botanichnyi Zhurnal. [Institut Botaniky, Akademiia Nauk Ukrainskoi URSR. Supersedes their Zhurnal.]

Bromel. Soc. Bull.—Bromeliad Society Bulletin. [Orlando, Florida.]

Bull. Acad. Bruxelles—Bulletins de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles. [Continued as "Bulletins de l'Académie Royale . . . de Belgique."]

Bull. Acad. Pol. Sci. Math. Nat. B. I.—Bulletin International de l'Académie Polonaise des Sciences, classe des sciences mathématiques et naturelles; série B: sciences naturelles I [Botany]. [Superseded by Bull. Acad. Pol. Sci. II.]

Bull. Acad. Pol. Sci. II.—Bulletin de l'Académie Polonaise des Sciences; classe deuxième (agrobiologie, biologie, sciences médicales). [Warsaw. Supersedes Bull. Acad. Pol. Sci. Math. Nat. B. I.]

Bull. Am. Mus. Nat. Hist.—Bulletin of the American Museum of Natural History. [New York.]

Bull. Biol. Fr. Belg.—Bulletin (Scientifique) Biologique de la France et de la Belgique. [Paris. Title varies.]

Bull. Jard. Bot. Buitenzorg—['sLands Plantentuin (Jardin Botanique de Buitenzorg).] Bulletin du Jardin Botanique. [Superseded by Reinwardtia.]

Bull. N. Y. Bot. Gard.—Bulletin of The New York Botanical Garden.

Bull. Sci. Acad. Roy. Belg.—Bulletin de la Classe des Sciences. Académie Royale de Belgique.

Bull. Soc. Linn. Paris—Bulletin Mensuel de la Société Linnéenne de Paris.

Bull. Soc. Philom. Paris—Bulletin des Sciences, par la Société Philomathique de Paris. [In 10 series, with various titles; 1807–1813 as Nouv. Bull. . . .]

Canad. Jour. Agr. Sci.—Canadian Journal of Agricultural Science. [Ottawa; continued as Canad. Jour. Pl. Sci.]

Canad. Jour. Genet. Cytol.—Canadian Journal of Genetics and Cytology. [Genetics Society of Canada.]

Canad. Jour. Pl. Sci.—Canadian Journal of Plant Science. [Agricultural Institute of Canada. Formerly Canad. Jour. Agr. Sci.]

Caryologia—Caryologia: giornale di citologia, citosistematica e citotgenetica. [Pisa; Florence.]

Chromosoma—Chromosoma; Zeitschrift für Zellkern- mit Chromosomenforschung. [Berlin.]

Claytonia—Claytonia. Quarterly journal of Virginia botany issued by Committee on Virginia Flora of the Virginia Academy of Science. [Superseded by Va. Jour. Sci.]

Colon. Pl. Anim. Prod. London—Colonial Plant and Animal Products. The quarterly journal of the Colonial Products Advisory Bureau (Plant and Animal). [Formerly part of the Bulletin of the Imperial Institute, London.]

Comm. Soc. Reg. Sci. Gott. II.—Commentationes Societatis Regiae Scientiarum Gottingensis Recentiores.

Comp. Bot. Mag.—Companion to the Botanical Magazine. (By W. J. Hooker.) [London, 1835–1837. Not to be confused with the "Companion to the Botanical Magazine" that forms a part of the Bot. Mag. itself, vols. 71–74.]

Contr. Ci. Bot. Univ. Buenos Aires—Contribuciones Científicas. Serie Botánica. [Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales.]

Contr. New S. Wales Natl. Herb.—Contributions from the New South Wales National Herbarium.

Cornell Agr. Exp. Sta. Mem.—Cornell University Agricultural Experiment Station. Memoir.

Denkschr. Akad. München—Denkschriften der Königlichen Akademie der Wissenschaften zu München.

Denkschr. Akad. Wien Math. Naturw.—Denkschriften der Kaiserliche Akademie der Wissenschaften, Wien. Mathematisch-Naturwissenschaftliche Klasse. [Continued as Denkschr. Österr. Akad.]

Denkschr. Österr. Akad.—Denkschriften der österreichische Akademie der Wissenschaften, Wien. Mathematisch-Naturwissenschaftliche Klasse.

Dict. Class. Hist. Nat.—Dictionnaire Classique d'Histoire Naturelle. [Paris.]

Dict. Sci. Nat.—Dictionnaire des Sciences Naturelles . . . par plusieurs professeurs du Jardin du Roi, et des principales écoles de Paris.

Dusenia—Dusenia; publicatio periódica de scientia naturali. [Curitiba.]

Edinb. New Philos. Jour.—Edinburgh New Philosophical Journal. [Continuation of Edinb. Philos. Jour.]

Edinb. Philos. Jour.—Edinburgh Philosophical Journal. [Continued as Edinb. New Philos. Jour.]

Ess. Philos. Soc. Edinb.—Essays and Observations, physical and literary. [Philosophical Society of Edinburgh.]

Evolution—Evolution. International journal of organic evolution. [The Society for the Study of Evolution.]

Exp. Cell Res.—Experimental Cell Research. [International Society for Cell Biology.]

Fl. Males.—Flora Malesiana, being an account of the Malaysian flora. [Flora Malesiana Foundation, Leyden.]

Garden Forest—Garden and Forest. A journal of horticulture, landscape art and forestry. [New York.]

Garden London—The Garden. An illustrated weekly journal of horticulture in all its branches. [London.]

Gartenflora—Gartenflora. [Deutsche Gartenbau-Gesellschaft.]

Gent. Mag.—Gentleman's Magazine; and historical chronicle. [London. Subtitle varied.]

Ges. Naturf. Freunde Berlin Mag.—Der Gesellschaft Naturforschender Freunde zu Berlin Magazin für die neusten Entdeckungen in der gesammten Naturkunde. [1807–1818. Superseded Ges. Naturf. Freunde Berlin Neue Schr.]

Ges. Naturf. Freunde Berlin Neue Schr.—Der Gesellschaft Naturforschender Freunde zu Berlin Neue Schriften. [1794–1803. Superseded Schr. Ges. Naturf. Freunde Berlin. Superseded by Ges. Naturf. Freunde Berlin Mag.]

Grana Palyn.—Grana Palynologia. An international journal of palynology. [Stockholm.]

Hedwigia—Hedwigia. Organ für Kryptogamenkunde und Phytopathologie nebst Repertorium für kryptogamische Literatur. [Dresden. Subtitle varied. Superseded by Nova Hedwigia.]

Hist. Acad. Roy. Sci. Paris Mém.—Histoire de l'Académie Royale des Sciences. Année . . . Avec les mémoires de mathématique & de physique, pour la même année. Tirés des registres de cette académie. [Paris.]

Hortic. Univ.—L'Horticulteur Universel. [Paris.]

Inst. Nac. Pesquisas Amaz. Bot. Publ.—[Conselho Nacional de Pesquisas.] Instituto Nacional de Pesquisas de Amazônia. Botânica. Publicação. [Rio de Janeiro.]

Inst. Paran. Publ.—Instituto Paranaense de Botânica. [Publicação. Curitiba.]

Iowa Nat.—The Iowa Naturalist. [Iowa City.]

Jahrb. Bot. Gart. Berlin—Jahrbuch des Königlichen botanischen Gartens und des botanischen Museums zu Berlin.

Jap. Jour. Genet.—Japanese Journal of Genetics. [Genetic Society of Japan. Name of society varies.]

Jour. Acad. Phila.—Journal of the Academy of Natural Sciences of Philadelphia.

Jour. Bot. Desvaux—Journal de Botanique, appliquée à l'agriculture, à la pharmacie, à la médecine et aux arts. Rédigé par N. A. Desvaux. [Paris, 1808–1816. In two series, the first entitled "Journal de Botanique rédigé par une société de botanistes." The two vols. of the first series appeared in 1808, 1809. The first vol. of of the second series has on the t.-p. "Seconde année. Tome 3e."]

Jour. Bot. Hooker—The Journal of Botany, being a second series of the Botanical Miscellany; . . . By William Jackson Hooker. [London, 1834–1842. Succeeded by London Jour. Bot.]

Jour. Bot. Kew Misc.—Hooker's Journal of Botany and Kew Garden Miscellany. Edited by Sir William Jackson Hooker. [1849–1857. Continuation of London Jour. Bot. Not to be confused with Bot. Misc. Hooker, q. v.]

Jour. Bot. Morot—Journal de Botanique. Directeur: M. Louis Morot. [Paris, 1887–1913.]

Jour. Bot. Schrader—Journal für die Botanik. Herausgegeben von Medicinalrath Schrader. [Göttingen, 1799–1801. Superseded by Neues Jour. Bot. Schrader. The vols. and parts are confused in their numbering. It is necessary to use the year for the volume-indication.]

Jour. Coll. Sci. Univ. Tokyo—Journal of the College of Science, (Imperial) University of Tokyo, Japan. [Continued as Jour. Fac. Sci. Univ. Tokyo Bot.]

Jour. Hattori Bot. Lab.—The Journal of the Hattori Botanical Laboratory. Devoted to bryology. [Tokyo.]

Jour. Hist. Nat. Paris—Journal d'Histoire Naturelle; rédigé par MM. Lamarck, Brugière . . . [Paris, 1792, two vols. only.]

Jour. Phys. Chim. Hist. Nat. Arts—Journal de Physique, de Chimie, d'Histoire Naturelle et des Arts. [Continuation of Obs. Phys. Chim. Hist. Nat. Arts.]

Jour. Proc. Linn. Soc. Bot.—Journal of the Proceedings of the Linnaean Society. Botany. [1855–1864. Continued as Jour. Linn. Soc. Bot.]

Jour. Roy. Asiat. Soc. Bengal—Journal of the (Royal) Asiatic Society of Bengal, Calcutta.

Jour. Sci. Res. Indon.—Journal for Scientific Research in Indonesia. The official monthly of the Organization for Scientific Research in Indonesia. [Title varies.]

Jour. Sect. Moscou Soc. Bot. Russ.—see Zhur. Moskov. Otd. Russ. Bot. Obshch.

Jour. Soc. Bot. Russ.—see Zhur. Russ. Bot. Obsheh.

Kosmos Stuttgart—Kosmos, Handweiser für Naturfreunde. [Gesellschaft der Naturfreunde, Stuttgart.]

Linnaea—Linnaea. Ein Journal für die Botanik . . . oder, Beiträge zur Pflanzenkunde. [Berlin; Halle. Merged with Jahrb. Bot. Gart. Berlin. Subtitle varies.]

Linnéska Samfund. Handl.—Linnéska Samfundets Handlingar. [Stockholm, 1832. Only one vol.]

London Edinb. Dubl. Philos. Mag.—London, Edinburgh and Dublin Philosophic Magazine and Journal of Science. [London. Title varies greatly: Philosophical Magazine; Tilloch's Philosophical Magazine; Philosophical Magazine and Journal; etc.]

London Jour. Bot.—The London Journal of Botany; . . . by Sir W. J. Hooker, . . . [1842–1848. Successor of Jour. Bot. Hooker. Succeeded by Jour. Bot. Kew. Misc. Not to be confused with Jour. Bot. London.]

Mag. Bot. Römer & Usteri—Magazin für die Botanik herausgegeben von Joh. Jacob Römer und Paulus Usteri. [Zürich, 1785–1790. First title was "Botanisches Magazin." Superseded by "Neues Magazin für die Botanik."]

Mag. Zool. Bot.—Magazine of Zoology and Botany. [Edinburgh; London. United with Comp. Bot. Mag. to form Ann. Nat. Hist., which became Ann. Mag. Nat. Hist.]

Med. Repos. N. Y.—The Medical Repository of New York. [Series 2 as "The Medical Repository. Second hexade."]

Meehans' Monthly—Meehans' Monthly. A magazine of horticulture, botany and kindred subjects. [Philadelphia.]

Mém. Acad. St. Pétersb. Sav. Étr.—Mémoires présenté à l'Académie Impériale des Sciences de St.-Pétersbourg par divers savans. [At foot of first page of each signature appears "Mémoires des savants étrangers."]

Mém. Acad. Sci. Berlin—Mémoires de l'Académie Royale des Sciences et Belles-lettres depuis l'avènement de Fréderic Guillaume II au trône, avec l'histoire pour le même temps. [Berlin, 1786–1797.]

Mém. Acad. Sci. Paris—Mémoires de l'Académie (Royale) des Sciences. [Paris, 1729–1809. Succeeded by "Mémoires de l'Institut National des Sciences et Arts. Sciences mathématiques et physiques."]

Mém. Acad. Toulouse—Mémoires de l'Académie des Sciences, Inscriptions et Belles-lettres de Toulouse. [1782–1797.]

Mem. Am. Acad.—Memoirs of the American Academy of Arts and Sciences. [Boston.]

Mem. Cong. Ci. Méx. VI. Biol.—[IV Centenario de la Universidad de México (1551–1951).] Memoria del Congreso Científico Mexicano VI. Ciencias biológicas.

Mém. Cour. Sav. Etr. Acad. Roy. Belg.—[Académie Royale des Sciences, des Lettres et des Beaux-arts de Belgique.] Mémoires Couronnés et Mémoires des Savants Étrangers. [Vols. 1–5 as "Mémoires sur les questions . . . qui ont remportés les Prix; . . . "]

Mem. Mus. Goeldi—Memorias do Museu Goeldi (Museu Paraense de Historia natural e Ethnographia]. [Belém.]

Mém. Mus. Hist. Nat. Paris—Mémoires du Muséum d'Histoire Naturelle. [Paris, 1815–1832.]

Mém. Soc. Hist. Nat. Paris—Mémoires de la Société d'Histoire Naturelle de Paris. [1799, 1823–1834.]

Mem. Soc. Ital. Sci.—Memorie (di matematica e di fisica) della Società Italiana delle Scienze. [Roma.]

Mém. Soc. Nat. Moscou—Mémoires de la Société Impériale des Naturalistes de Moscou. [1806–1823. Vol. 1 was entitled "Mémoires de la Société des Naturalistes de l'Université Impériale de Moscou."]

Mém. Soc. Phys. Hist. Nat. Genève—Mémoires de la Société de Physique et d'Histoire Naturelle de Genève.

Mem. Wernerian Soc.—Memoirs of the Wernerian Natural History Society. [Edinburgh.]

Mercurio Chil.—El Mercurio Chileno. [Santiago, 1828, 1829. 16 issues in one volume; no more published.]

Missouri Bot. Gard. Rep.—Missouri Botanical Garden. Annual Report.

Mitt. Bot. Gart. Berlin—Mitteilungen aus dem Botanischen Garten und Museum Berlin-Dahlem; früher Notizblatt. [Continuation of Notizbl. Bot. Gart. Berlin; continued as "Willdenowia."]

Muhlenbergia—Muhlenbergia. A monthly journal of botany. [Reno.]

Nat. Geneesk. Arch. Neerl. Ind.—Natuur- en Geneeskundig Archief voor Neêrland's-Indië. [Batavia.]

Nederl. Kruidk. Arch.—Nederlandsche Kruidkundig Archief. Verslagen en Mededeelingen der Koninklijke Nederlandsche Botanische Vereeniging. [Superseded by Acta Bot. Neerl.]

Neues Jour. Bot. Schrad.—Neues Journal für die Botanik. Herausgegeben vom Professor Schrader. [Erfurt, 1806–1810. Superseded Jour. Bot. Schrader.]

New Fl. Silva—New Flora and Silva. [London.]

Norske Vid. Selsk. Skr.—Det Kongelige Norske Videnskabers Selskabs Skrifter.

Northw. Nat. Brit.—North Western Naturalist. [Arbroath, Scotland. Superseded "Lancashire & Cheshire Naturalist."]

Notes Bot. Gard. Edinb.—Notes from the Royal Botanic Garden. [Edinburgh.]

Notizbl. Bot. Gart. Berlin—Notizblatt des Botanischen Gartens und Museums zu Berlin-Dahlem. [Continued as Mitt. Bot. Gart. Berlin.]

Nouv. Ann. Mus. Paris—Nouvelles Annales du Muséum d'Histoire Naturelle. [Paris. Continued as Arch. Mus. Hist. Nat. Paris.]

Nouv. Bull. Soc. Philom. Paris—Nouveau Bulletin des Sciences, par la Société Philomathique de Paris. [See Bull. Soc. Philom. Paris.]

Nova Acta Soc. Sci. Upsal.—Nova Acta Regiae Societatis Scientiarum Upsaliensis.

Nova Hedwigia—Nova Hedwigia. Zeitschrift für Kryptogamenkunde. [Weinheim. Supersedes Hedwigia.]

Nucleus—Nucleus: an international journal of cytology and allied topics. [Calcutta.]

Obs. Phys. Hist. Nat. Arts—Observations sur la Physique, sur l'Histoire Naturelle et sur les Arts. [Paris. Continued as Jour. Phys. Chim. Hist. Nat. Arts.]

Oesterr. Bot. Wochenbl.—Oesterreichische Botanische Wochenblatt. [Wien. Vols. 1–7; continued as Oesterr. Bot. Zeitschr.]

Orchis—Orchis. Mitteilungen des Orchideenausschusses des Vereins zur Beförderung des Gartensbaues. Beilage zur "Gartenflora." [Berlin. Subtitle varied. Not to be confused with an earlier "Orchis" (1906, 1907), "Monatsschrift der Deutschen Gesellschaft für Orchideenkunde."]

Pflanzenareale—Pflanzenareale. [Jena.]

Pflanzenreich—Das Pflanzenreich; regni vegetabilis conspectus. [Leipzig.]

Philip. Agr.—The Philippine Agriculturist. [The College of Agriculture, University of the Philippines.]

Philip. Jour. Agr.—Philippine Journal of Agriculture. [Manila. Supersedes Philip. Agr. Rev.]

Phytopath. Zeitschr.—Phytopathologische Zeitschrift. [Berlin.]

Pl. World—The Plant World. A monthly journal of general botany. [Continued as "Ecology."]

Proc. AAAS—Proceedings of the American Association for the Advancement of Science. [Continued as "American Association for the Advancement of Science. Summarized Proceedings."]

Proc. Bot. Soc. Brit. Isles—Proceedings of the Botanical Society of the British Isles. [Supersedes their "Yearbook."]

Proc. Bristol Nat. Soc.—Proceedings of the Bristol Naturalist's Society.

Proc. Canad. Phytopath. Soc.—Proceedings of the Canadian Phytopathological Society.

Proc. Linn. Soc. New S. Wales—The Proceedings of the Linnean Society of New South Wales.

Proc. Trans. Tex. Acad.—Proceedings and Transactions of the Texas Academy of Science.

Protoplasma—Protoplasma; internationale Zeitschrift für physikalische Chemie des Protoplasten. [Leipzig.]

Publ. Atkins Inst. Arnold Arb.—Publications of the Atkins Institution of the Arnold Arboretum of Harvard University.

Quart. Bull. Alp. Gard. Soc.—Quarterly Bulletin of the Alpine Garden Society.

Quart. Jour. Sci. Lit. Arts—Quarterly Journal of (Science, Literature,) and (the) Art(s). [Royal Institution of Great Britain.]

Revista Braz.—Revista Brazileira; jornal de sciencias, lettras e artes. [Rio de Janeiro.]

Revue Hort.—Revue Horticole. Journal d'horticulture pratique. [Paris.]

Revue Sci. Nat. Auvergne—Revue des Sciences Naturelles d'Auvergne. [Société d'Histoire Naturelle d'Auvergne.]

Samml. Phys.-oek. Aufs.—Sammlung Physikalisch-ökonomischer Aufsätze, zur Aufnahme des Naturkunde und deren damit verwandten Wissenschaften in Böhmen; herausgegeben von Franz Wilibald Schmidt. [Only one vol., 1795.]

Schr. Berlin. Ges. Naturf. Freunde—Schrifter der Berlinischen Gesellschaft Naturforschender Freunde.

Sellowia—Sellowia. Anais Botânicos do Herbário "Barbosa Rodrigues." [Conselho Nacional de Pesquisas. Continuation of Anais Herb. Barbosa Rodrigues.]

Skr. Naturh.-Selsk. Kjøbenh.—Skrivter af Naturhistorie-Selskabet. [Kjøbenhavn.]

Smithson. Contr. Knowl.—Smithsonian Contributions to Knowledge. [Smithsonian Institution, Washington.]

Soviet. Bot.—Sovietskaya Botanika. [Merged with Bot. Zhur.]

Syll. Pl.—Sylloge Plantarum Novarum itemque minus cognitarum. [Regensburg, 1824–1828.]

Symb. Antill.—Symbolae Antillanae, seu fundamenta florae Indiae occidentalis. [Berlin. Largely by Urban.]

Taxon—Taxon. Official news bulletin of the International Association for Plant Taxonomy.

Tex. Jour. Sci.—Texas Journal of Science. [Texas Academy of Science.]

Trans. Cambridge Philos. Soc.—Transactions of the Cambridge [England] Philosophical Society.

Trans. Hort. Soc. London—Transactions of the Horticultural Society of London. [Later the Royal Horticultural Society.]

Trans. Roy. Canad. Inst.—Transactions of the (Royal) Canadian Institute.

Trans. Roy. Soc. New Zealand—Transactions and Proceedings of the Royal Society of New Zealand. [Formerly the Institute of . . .]

Trans. San Diego Soc. Nat. Hist.—Transactions of the San Diego Society of Natural History.

U. S. Dep. Agr. Bull.—United States Department of Agriculture. Bulletin. [Also as "Bulletin of the . . . "]

U. S. Dep. Agr. Bur. Pl. Ind. Bull.—United States Department of Agriculture. Bureau of Plant Industry—Bulletin.

U. S. Dep. Agr. Bot. Circ.—United States Department of Agriculture. Division of Botany. Circular.

U. S. Dep. Agr. Farmers' Bull.—United States Department of Agriculture. Farmers' Bulletin.

U. S. Dep. Agr. Forest Serv. Misc. Publ.—United States Department of Agriculture. Forest Service. Miscellaneous Publication.

U. S. Dep. Agr. Tech. Bull.—United States Department of Agriculture. Technical Bulletin.

Univ. Córdoba Trab. Mus. Bot.—Universidad Nacional de Córdoba [Argentina]. Facultad de Ciencias Exactas, Físicas y Naturales. Trabajos del Museo Botánico.

Verh. Batav. Genootsch.—Verhandelingen van het (Koninklijk) Bataviaasch Genootschap van Kunsten en Wetenschappen.

Vet.-akad. Stockholm Handl.—(Kongl.) Vetenskaps-akademiens Handlingar. [Stockholm. In two series, between which (1780–1812) came the "Nya Handlingar."]

Vet.-akad. Stockholm Nya Handl.—Kongl. Vetenskaps Academiens Nya Handlingar. [See under Vet.-akad. Stockholm Handl.]

Vid. Medd. Nat. For. Kjøbenh.—Videnskabelige Meddelelser fra (den) (Dansk) Naturhistorisk Forening i Kjøbenhavn.

W. Va. Univ. Bull.—West Virginia University Bulletin. [Issued in "series" and "numbers."]

Webbia—Webbia. [Instituto Botanico dell' Università di Firenze.]

Willdenowia—Willdenowia. Mitteilungen aus dem Botanischen Garten und Museum Berlin-Dahlem. [Continuation of Mitt. Bot. Gart. Berlin.]

Zeitsch. Naturf.—Zeitschrift für Naturforschung. [Wiesbaden.]

Zhur. Inst. Bot. URSR—Zhurnal Institutu Botaniky Akademii Nauk URSR. [Also as "Journal de L'Académie des Sciences de la RSS d'Ukraine." Superseded by Bot. Zhur. Kiev.]

Zhur. Mosk. Otd. Russ. Bot. Obshch.—Zhurnal Moskovskovo Otdeleniia Russkovo Botanicheskovo Obshchestva. [Also as "Journal de la Section de Moscou de la Société Botanique de Russie."]

Zhur. Russ. Bot. Obshch.—Zhurnal Russkovo Botanicheskovo Obshchestva. [Also as "Journal de la Société Botanique de Russie," etc.]

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Notes on some grasses. XI. Leaf structure of *Eriachne*

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ABSTRACT

TATEOKA, TUGUO, (U. Montréal, Canada.) Notes on some grasses XI. Leaf structure of Eriachne. Bull. Torrey Bot. Club 88(1): 11–20, 1961.—Leaf anatomy and histology of 24 species of *Eriachne* were examined. In epidermal structure the, belong to Prat's (1936) panicoid type, and their features appearing in trans-sections are also very close to Brown's (1958) panicoid and chloridoid types. The systematic difference of *Eriachne* from Aveneae is discussed from the viewpoints of morphology and leaf structure.

During the course of studies toward the revision of Aveneae, the author found various genera which need further examination as to their systematic position although they are conventionally treated as belonging to this tribe. *Eriachne*, which comprises about 35 species, represents one such genus. The members of this genus are mostly indigenous in Australia, and a few species extend to tropical Asia. *E. triseta*, which is distributed from New Guinea to Ceylon and is often referred to an independent genus, *Massia*, is apparently related to the other *Eriachne*, especially through such species as *E. nervosa*, and *E. rara*. Their systematic positions in the grass system should be considered as close to one another.

As a consequence of many studies along not only morphological but also various new lines of approach, such as cytology, anatomy and embryology, the delimitation of Aveneae has been greatly changed from the original concept. *Danthonia* and its relatives were referred to this tribe until Hubbard (1948) established the tribe Danthonieae, which is now generally considered to be close to Arundineae but remote from (true) Aveneae. On the other hand, the relationship between Aveneae s. str. and Agrosteae s. str. has been pointed out by various authors from such points of view as leaf structure (Prat, 1936; Brown, 1958; a.o.), cytology (Avdulov, 1931; Hunter, 1934; a.o.), embryo anatomy (Reeder, 1957), and external morphology (Ohwi, 1942; Pilger, 1945). In some recently proposed systems (Hylander, 1953; Pilger, 1954; Tateoka, 1957; a.o.), the members of

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Agrosteae s. str. and Aveneae s. str. are treated as belonging to one and the same tribe.

An initial suggestion for such a systematic revision of these grasses was given by Avdulov (1931). He recognized two groups within Aveneae sensu Hackel (1887). The first is characterized by the awn of the lemma (when present) being dorsal. It is mostly distributed in the Northern Hemisphere and is favored by a cooler and moister climate. The second group is more southerly in distribution and, according to Avdulov (1931), the awn of the lemma (when present) usually arises from the sinus of the lobes. Avdulov (1931) enumerated in the second group the genera *Eriachne, Zenkeria, Coelachne, Micraira, Tristachya, Trichopteryx, Prionanthium, Afrachneria, Anisopogon, Danthonia* and *Amphibromus.*

Avdulov's (1931) suggestion was very valuable and its essence was supported by later investigations. Subsequent studies, however, have shown that the genera referred to Avdulov's second group should not be put together but should be placed in various other tribes. *Coelachne* is now usually

TABLE 1. *List of the species examined*

Eriachne anomala Hartley	*E. festucacea* F. Muell.
E. ciliata R. Br.	*E. melicacea* F. Muell.
E. isingiana J. M. Black	*E. benthamii* Hartley
E. sulcata Hartley	*E. pallescens* R. Br.
E. ovata Nees	*E. glauca* R. Br.
E. sclerantoides F. Muell.	*E. avenacea* R. Br.
E. nervosa Ewart et Cookson	*E. obtusa* R. Br.
E. triodioides Domin	*E. armitii* F. Muell.
E. rara R. Br.	*E. mucronata* R. Br.
E. pulchella Domin	*E. helmsii* Domin
E. aristidea F. Muell.	*E. squarrosa* R. Br.
E. insularis Domin	*E. triseta* Nees

ascribed to Isachneae (Hubbard, 1943; Potztal, 1952; Pilger, 1954; Tateoka, 1957). The peculiarities of *Micraira* were disclosed by Philipson (1935) and Potztal (1953). *Tristachya* and *Trichopteryx* are now referred to Arundinelleae (Hubbard, 1936; Pilger, 1954; Chippindall, 1955; Conert, 1957). The leaf structure of *Prionanthium* was studied by de Wet (1956) and Hansen and Potztal (1954). They showed that the epidermal traits of leaves of *Prionanthium* are panicoid, whereas its features shown in leaf trans-sections are festucoid. De Wet (1956) found similar characteristics of leaf anatomy and histology in *Afrachneria. Amphibromus* seems closely related to (true) Aveneae in view of its morphology (Parodi, 1958; Holub, 1958), although its distribution in South America and Australia is very curious for the Aveneae, as pointed out by Swallen (1931). *Danthonia* was studied by many investigators (Stebbins and Love, 1941; de Wet, 1954, 1956; Reeder, 1957; a.o.), and as mentioned above, the genus and its relatives are now generally referred to as a separate tribe, Danthonieae.

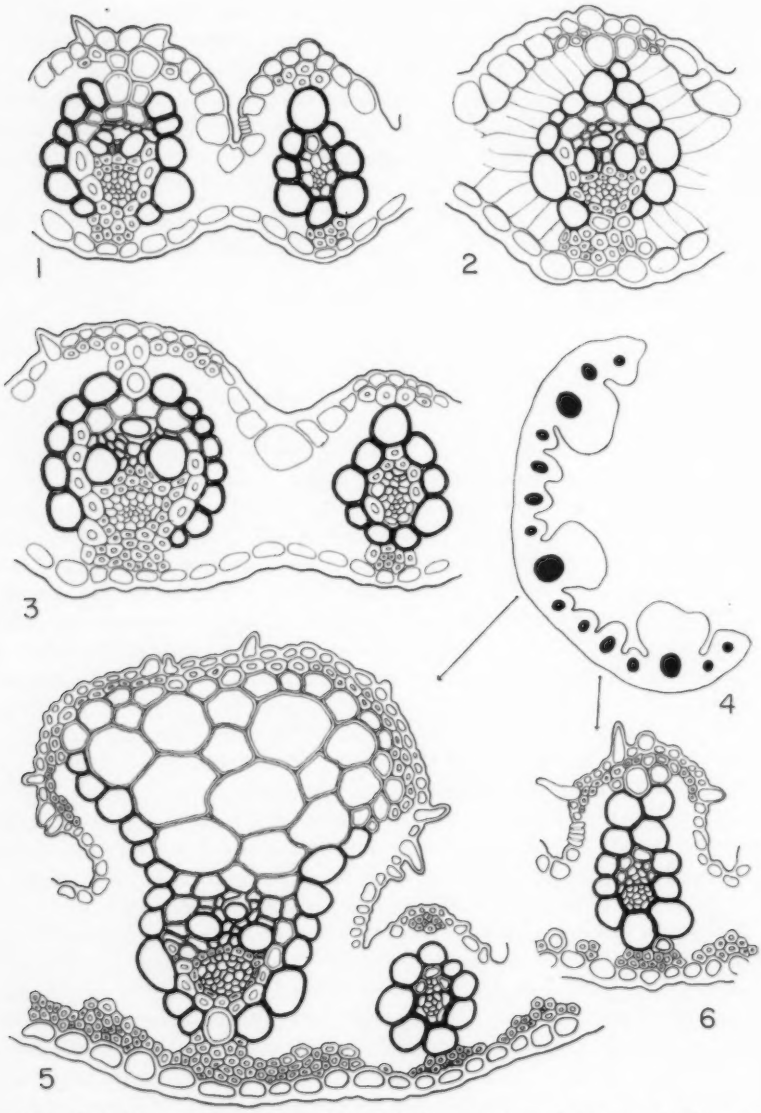
As to the systematic position of *Eriachne*, no noteworthy study has been published. Although Breakwell (1915), Vickery (1935), a.o., presented the anatomical studies of leaves of some Australian grasses, *Eriachne* has been completely neglected in these works. Some observations on leaf structure, the value of which in grass systematics has already been established by Prat (1936), Avdulov (1931), Brown (1958), a.o., are reported in the present paper for the genus *Eriachne*.

MATERIALS AND METHODS. A total of 24 species, listed in Table 1, were examined. Fresh leaves were not available, so the observations throughout were made on leaves taken from herbarium sheets. The material was mostly obtained from the United States National Herbarium in Washington. The dried leaves were macerated in cold water. After soaking one night, the leaves were cut by hand with the aid of a razor blade.

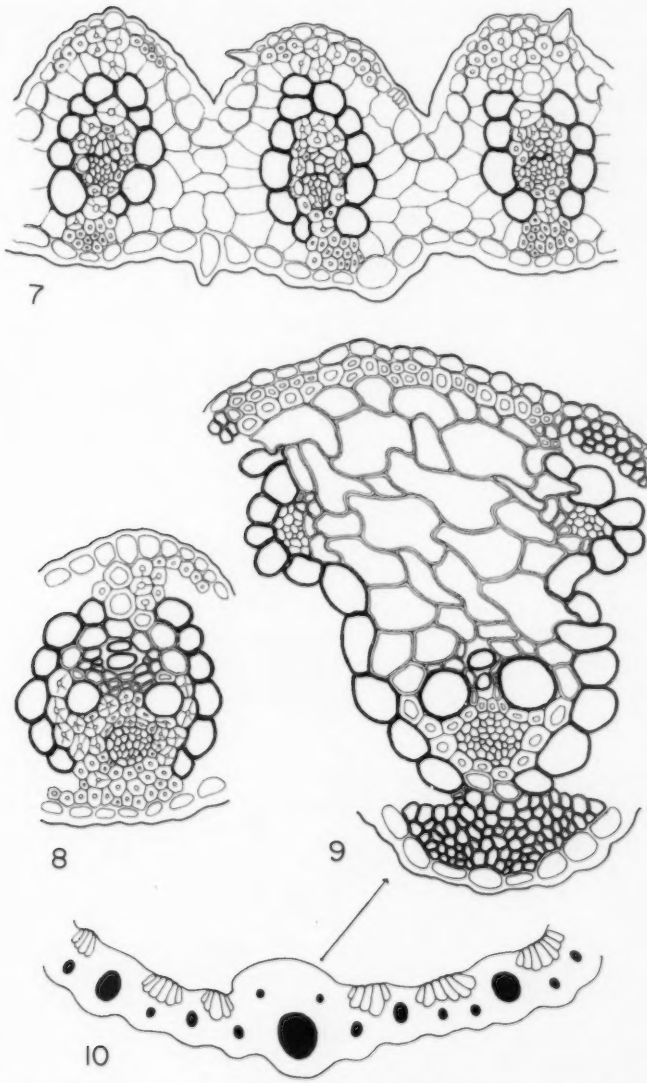
OBSERVATIONS. In spite of the diverse features of external morphology, the 24 species observed closely resemble one another in the anatomical features of their leaves. In all of them, vascular bundles are surrounded by a well developed parenchyma sheath which is composed of thick-walled cells with plenty of chloroplasts (Figs. 1–3, 5–9). The inner bundle sheath (endodermis) is usually rather weakly developed. In most species the cells which compose the lower part of the inner sheath are very thick-walled, but they are replaced by thin-walled cells along the upper part of the vascular bundle. In such species, however, as *E. ovata* and *E. sclerantoides*, the inner bundle sheath is relatively well developed, usually being composed of thick-walled cells both in the upper and lower parts. The midrib is anatomically similar to the side nerves in the species observed except in *E. obtusa*. In this species, the midrib has two very small vascular traces in the adaxial surface besides a large vascular bundle in the abaxial surface (Figs. 9 and 10). Mesophyll cells are usually not radially arranged (Fig. 7), but in *E. rara*, *E. pulchella*, etc., their arrangement is radial around the parenchyma sheath of the vascular bundle (Fig. 2). The motor cells are usually scantily developed, but in *E. obtusa*, *E. sclerantoides*, *E. mucronata*, etc., they are well developed (Fig. 10).

The species observed are also very similar to one another in epidermal features. All species examined have bicellular microhairs. These microhairs are threadlike, and the cell membranes of the upper cell are thinner than those of the lower cells. Siliceous cells are mostly of saddle shape, and are broader than long. In a few species, such as *E. festucacea*, *E. ovata*, *E. isingiana*, siliceous cells are somewhat elongated, being almost equal in length and width. When long hairs are present, they always carry a sheath of epidermal cells at the base. The stomata are oval or round in outline.

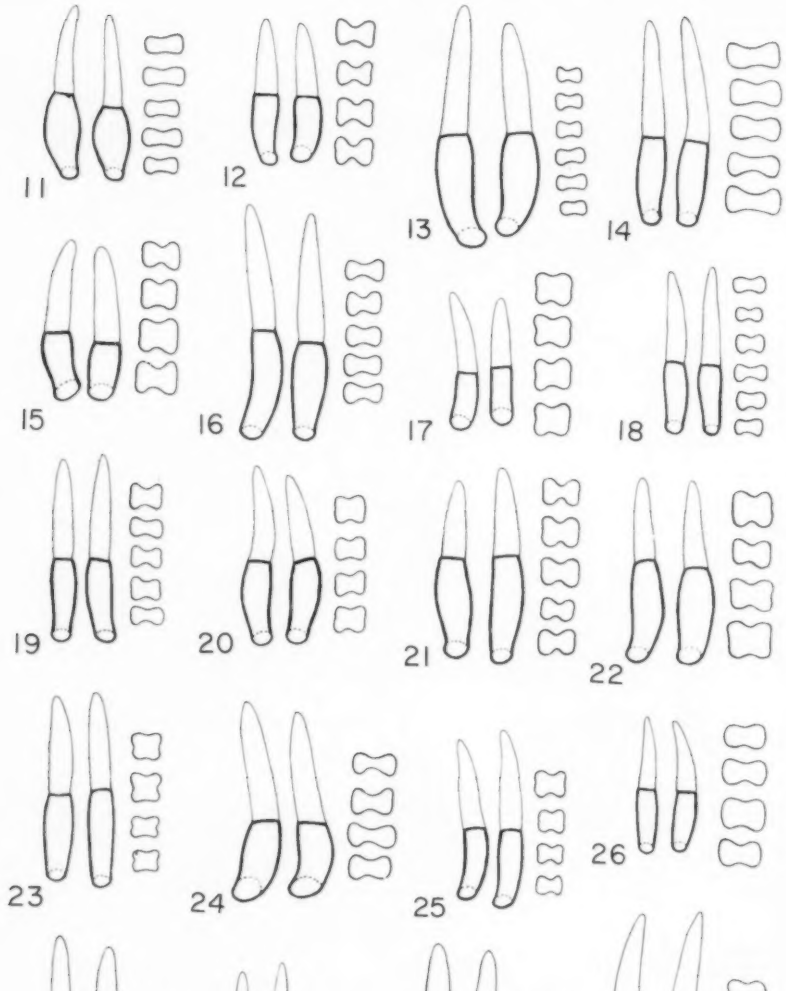
Brown (1958) indicated that the parenchyma sheath cells of the mem-



FIGS. 1–6. Trans-sections of leaves. 1, *Eriachne squarrosa*. 2, *E. rara*. 3, *E. armitii*. 4–6, *E. triseta*. 1–3, × 300. 4, × 55. 5–6, × 290.



FIGS. 7–10. Trans-sections of leaves. 7–8, *Eriachne festucacea*. 9–10, *E. obtusa*. 7–8, × 290. 9, × 250. 10, × 60.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bers belonging to his panicoid, chloridoid and aristidoid types of leaf anatomy have specialized plastids for starch storage, whereas in his festucoid, bambusoid and arundinoid types such a differentiation is lacking. Only dried leaves are used in the present study, so it was very difficult to decide whether the parenchyma sheath cells of *Eriachne* have specialized plastids or not. Nevertheless, the leaf anatomy of *Eriachne* apparently closely resembles Brown's (1958) panicoid and chloricoid types as regards the development of the parenchyma and inner bundle sheaths, the arrangement of mesophyll cells and the distribution of chloroplasts. In epidermal features, *Eriachne* definitely belongs to Prat's (1936) panicoid type.

E. triseta, which is characterized by the elongated awns exserted from the tip of the two keels of the palea and often referred to an independent genus, *Massia*, is very closely related to the other *Eriachne* species in leaf structure (Figs. 4–6, 29). Regarding the development of the parenchyma and inner bundle sheaths, the arrangement of mesophyll cells, the shapes of siliceous cells and stomata, and the presence of threadlike bicellular microhairs, nothing can be found which indicates a deviation of *E. triseta* from the other species.

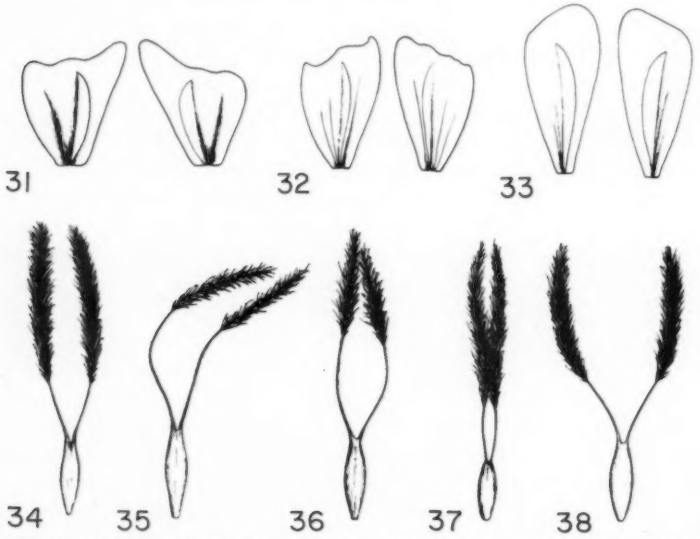
DISCUSSION. In classical systems of the grass family, *Eriachne* was usually placed in Aveneae (Bentham and Hooker, 1883; Hackel, 1887; Camus and Camus, 1922; Bews, 1929; Hubbard, 1934; a.o.). This treatment was apparently based on the morphological characters: spikelets 2-flowered, disarticulating between the florets and above the glumes, both the lower and the upper florets hermaphrodite, the upper and the lower glumes almost equal in size and longer than or as long as the lemma (rarely somewhat shorter). However, the awn of the lemma of *Eriachne* arises from the tip and not from the back of the lemma as in most Aveneae. Based on this characteristic, *Eriachne* was sometimes treated as a separate subtribe (e.g., Keng et al., 1957) or referred to Festuceae (Gardner, 1952). The affinity of *Eriachne* to Aveneae was also suspected by some systematists of the old time. For example, Bentham (1881) included *Eriachne* in Isachneae, although in 1883 he united the members of his Isachneae and Aveneae under the name of the latter tribe.

In spite of the resemblance of spikelet morphology, the leaf structure of *Eriachne* described above is remarkably different from that of Aveneae. In Aveneae, the vascular bundles are surrounded by a well developed inner

FIGS. 11–30. Bicellular microhairs (left) and siliceous cells (right) found in the lower epidermis of leaves of *Eriachne*. ×450. 11, *E. ciliata*. 12, *E. nervosa*. 13, *E. anomala*. 14, *E. obtusa*. 15. *E. aristidea*. 16, *E. pallescens*. 17, *E. festucacea*. 18, *E. triodioides*. 19, *E. armitii*. 20, *E. melicacea*. 21, *E. helmsii*. 22, *E. mucronata*. 23, *E. isingiana*. 24, *E. sulcata*. 25, *E. rara*. 26, *E. glauca*. 27, *E. insularis*. 28, *E. squarrosa*. 29, *E. triseta*. 30, *E. ovata*.

bundle sheath, which is composed of thick-walled cells, and a very indistinct parenchyma sheath. The cells of the parenchyma sheath are small and thin-walled. In the case of *Eriachne*, the parenchyma sheath is well developed and thick-walled, whereas the inner sheath is not so well or only somewhat developed. Also, in epidermal traits, *Eriachne* belongs to the panicoid type which is characterized by the threadlike bicellular microhairs, dumbbell-, cross- or saddle-shaped siliceous cells, the stomata oval in outline, and the hairs with the sheath of epidermal cells at the base. In contrast to *Eriachne*, the epidermal features of Aveneae are of the festucoid type. They lack the bicellular hairs, and the siliceous cells are rectangular or round.

Although *Eriachne* and Aveneae share some resemblance in spikelet features as mentioned above, the differences between them are clearly in-



FIGS. 31–33. Lodicules. 31, *Eriachne mucronata*. 32, *E. ovata*. 33, *E. triodioides*. FIGS. 34–38. Pistils. 34, *E. obtusa*. 35, *E. ovata*. 36, *E. nervosa*. 37, *E. squarrosa*. 38, *E. helmsii*.

dicated in such morphological features as lodicules and pistils. In Aveneae, the lodicules are mostly oblong, lanceolate or split into two halves and more or less acute (cf. Stebbins, 1956b; Reeder and Ellington, 1960; Hubbard, 1954). However, the lodicules of *Eriachne* are usually cuneate and truncate (Figs. 31–33) .The pistils of Aveneae, as a rule, have no distinct styles, but in *Eriachne* the styles are very clearly visible (Figs. 34–38). Stigmas of *Eriachne* are ordinarily dark-purple. Ohwi (1941) has noted that purple

stigmas are often found in eragrostoid grasses but are uncommon in festucoid grasses.

The resemblance in spikelets of *Eriachne* and Aveneae may be reasonably attributed to a parallel development. Stebbins (1956a, b), Hubbard (1946, 1948), Church (1949), a.o., indicated that the features appearing in the flowers themselves and in the caryopses are very important in grass systematics, and in flower characters the different positions of *Eriachne* and Aveneae are clearly shown. Considering these anatomical and morphological differences, the reference of *Eriachne* to Aveneae is quite inadequate.

Unfortunately, the chromosomes and embryo anatomy of *Eriachne* are still completely unknown. Lack of knowledge regarding these characters prevents a detailed discussion of the systematic position of *Eriachne* because they are very important in grass systematics together with morphological characters and leaf structure. Judging from the morphological and anatomical features, it seems that the affinity of *Eriachne* ought to be sought in some panicoid or danthonidoid groups. However, further studies are needed before putting forth conclusive remarks. In connection with the problem regarding the systematic position of *Eriachne*, further studies on Arundinelleae, Arthropogoneae, Isachneae, etc., and even those on some members of Danthonieae may also be necessary.

Literature Cited

Avdulov, N. 1931. Karyosystematische Untersuchung der Familie Gramineen. Bull. Appl. Bot., Genet. and Plant Breed. Suppl. 44. 428 pp.

Bentham, G. 1881. Notes on Gramineae. Jour. Linn. Soc. **19:** 14–134.

Bentham, G. and **Hooker, J. D.** 1883. Gramineae. In Genera Plantarum **3.** Pars 2. pp. 1074–1212.

Bews, J. W. 1929. The world's grasses. 408 pp. Longmans, Green and Co. London.

Breakwell, E. 1915. The anatomical structure of some xerophytic native grasses. Proc. Linn. Soc. N. S. Wales **40:** 42–55.

Brown, W. V. 1958. Leaf anatomy in grass systematics. Bot. Gaz. **119:** 170–178.

Camus, E. G. and **Camus, A.** 1922. Gramineae. *In* Flore générale de l'Indo-Chine. 7. pp. 202–650 .

Chippindall, L. K. A. 1955. A guide to the identification of grasses in South Africa. *In* The grasses and pastures of South Africa, pp. 1–527.

Church, G. L. 1949. A cytotaxonomic study of *Glyceria* and *Puccinellia*. Amer. J. Bot. **36;** 155–165.

Conert, H. J. Beiträge zur Monographie der Arundinelleae. Bot. Jb. **77:** 226–354.

De Wet, J. M. J. 1954. The genus *Danthonia* in grass phylogeny. Amer. J. Bot. **41:** 204–211.

———. 1956. Leaf anatomy and phylogeny in the tribe Danthonieae. Amer. J. Bot. **43:** 175–182.

Gardner, C. A. 1952. Flora of Western Australia. **1.** Part 1. Gramineae. pp. 400. Perth.

Hackel, E. Gramineae. *In* Nat. Pflanzenfamilien. **2.** Teil. 2. Abteilung.

Hansen, I. and **Potztal. E.** 1954. Beiträge zur Anatomie und Systematik der Leptureae. Bot. Jb. **76:** 251–270.

Holub, J. 1958. Bemerkungen zur Taxonomie der Gattung *Helictotrichon* Bess. Klášt. et Coll.: Philipp Maximilian Opiz und seine Bedeutung für die Pflanzentaxonomie. pp. 101–133.

Hubbard, C. E. 1943. Gramineae. *In* J. Hutchison, The families of flowering plants **2:** 199–229.

————. 1936. The genera of the tribe Arundinelleae. Kew Bull. 1936: 317–322.

————. 1943 *Limnopoa meeboldii* (C. E. C. Fischer) C. E. Hubbard. Hook. Ic. Pl. **5:** tab. 3432.

————. 1946. *Henrardia*, A new genus of the Gramineae. Blumea Suppl. **3:** 10–21.

————. 1948. The genera of British grasses. *In* J. Hutchinson, British Flowering Plants, pp. 284–348.

————. 1954. Grasses. 428 pp. Richard Clay and Co. Suffolk.

Hunter, A. W. S. 1934. A karyosystematic investigation in the Gramineae. Canad. J. Res. **11:** 213–241.

Hylander, N. 1953. Nordisk Kärlväxtflora **1.** 392 pp. Uppsala.

Keng, Y. L. et al. 1957. Claves generum of specierum Graminearum primarum Sinicarum Appendice nomenclatione systematica. 257 pp. Peking.

Ohwi, J. 1941. An account of the tribe Eragrosteae of Japan. II. Bot. Mag. Tokyo **55:** 309–313.

————. 1942. Gramina Japonica IV. Acta Phytotax. Geobot. **11:** 145–193.

Parodi, L. R. 1958. Gramineas bonaereases. (Quinta edicion). 142 pp. Buenos Aires.

Philipson, W. R. 1935. A grass with spiral phyllotaxis—*Micraira subulifolia*. Kew Bull. 1935: 324–326.

Pilger, R. 1945. Additamenta agrostologia. Bot. Jb. **74:** 1–27.

————. 1954. Das System der Gramineae. Bot. Jb. **76:** 281–384.

Potztal, E. 1952. Über die Blattanatomie der Isachneae. Bot. Jb. **75:** 551–569.

————. 1953. Über die Anatomie von *Micraira subulifolia* F. Muell. Bot. Jb. **76:** 134–138.

Prat, H. 1936. La systématique des Graminées. Ann. Sci. Nat. Bot. sér 10, **18:** 165–258.

Reeder, J. R. 1957. The embryo in grass systematics. Amer. J. Bot. **44:** 756–768.

Reeder, J. R. and **Ellington, M. A.** 1960. *Calamovilfa*, a misplaced genus of Gramineae. Brittonia **12:** 71–77.

Stebbins, G. L. 1956a. Taxonomy and the evolution of genera, with special reference to the family Gramineae. Evolution **10:** 235-245.

————. 1956b. Cytogenetics and evolution of the grass family. Amer. J. Bot. **43:** 890–905.

Stebbins, G. L. and **Love, R. M.** 1941. A cytological study of California forage grasses. Amer. J .Bot. **28:** 371–382.

Swallen, J. R. 1931. The grass genus *Amphibromus*. Amer. J. Bot. **18:** 411–415.

Tateoka, T. 1957. Miscellaneous papers on the phylogeny of Poaceae (10). Proposition of a new phylogenetic system of Poaceae. Jour. Jap. Bot. **32:** 275–287.

Vickery, J. W. 1935. The leaf anatomy and vegetative characters of the indigenous grasses of N. S. Wales. Proc. Linn. Soc. N. S. Wales **60:** 340–373.

BULLETIN OF THE TORREY BOTANICAL CLUB

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Forest ecology of ice storms

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ABSTRACT

LEMON, PAUL C. (State U. College of Education, Albany, N.Y.) Forest ecology of ice storms. Bull. Torrey Bot. Club 88(1): 21–29. Illus. 1961.—Glaze storms of destructive intensity, caused by certain frontal conditions, visit northern and eastern parts of the United States periodically; ice thickness occasionally exceeds 2 in. Resistance to glaze breakage is a complex matter, not simply related to one factor such as green wood strength, crown pattern, taxonomic group, exposure, and nature of the stand. The more resistant tree species are some of the dominants of climax forest communities. Several of the more susceptible species belong to early stages in succession, causing a slight acceleration of the rate of succession. A plea is made for improved and standardized glaze observations.

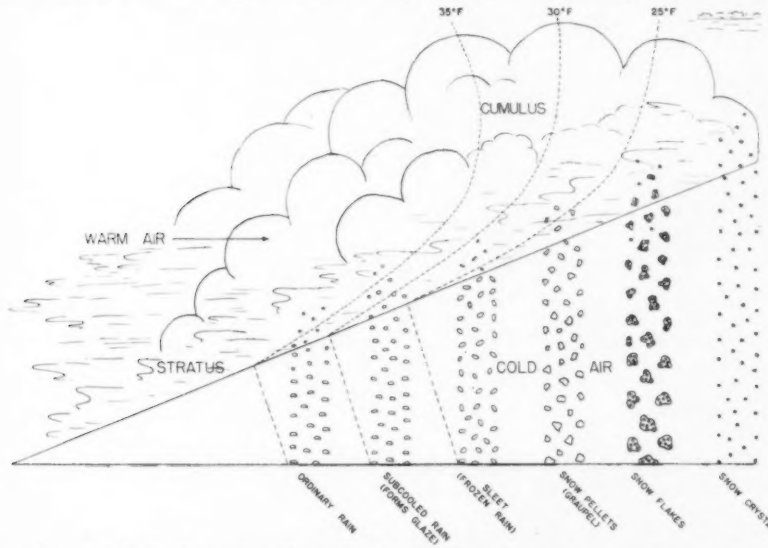

FIG. 1. Idealized diagram through a slowly advancing winter warm front showing all the forms of precipitation which might possibly develop.

Glaze is defined as a clear layer of ice formed by undercooled (supercooled, sub-cooled) water freezing on the surface of objects. Typically, glaze formation occurs when a winter warm front follows ground level temperature below 32 degrees F., as described by Christie and Chartier (1943). If the temperatures within a cloud are very low, snow or some other ice form will be produced and fall to earth in solid state. But if con-

ditions are such that rain drops form they may fall through layers of cooler air and reach the earth undercooled, occasionally to 15 degrees F. The formation of ice upon impact is dependent upon the specific heat and thermal conductivity of the object struck.

The diagram presented as figure 1 illustrates a glaze-forming warm front, along with various associated hydrometeors. The angle of the plane in the illustration is much exaggerated since it usually rises about one mile per 100 miles of horizontal distance. Thus, the isotherms would be more widely space and might cause serious glaze zones exceeding 50 miles width. In addition to the common warm front ice storm, glaze can also be formed by certain types of stationary fronts, occluded fronts or, infrequently, even cold fronts.

FIG. 2. General map showing the extent of icing in the United States during the worst glaze storms. (Modified, after U. S. National Bureau of Standards, 1948)

Glaze incidence. Glaze formation results when undercooled rain strikes cold objects and freezes. Talman (1931) states that destructive glaze storms are rare in Europe. However, disastrous storms strike some part of North America every winter. Figure 2 illustrates the general intensity of glaze storms in the United States. The National Bureau of Standards (1948) based the mapping of various glaze areas upon experience of wire maintenance firms and recommends, for example, that lines in the heavy glaze area be strong enough to carry one-half inch thick ice in winds reaching 40 miles per hour. Under these conditions many large tree branches break, this being the principal cause of damage to lines.

New York State has suffered serious glaze damage in 1884, 1909, 1914, 1922–23, 1925, 1929–30, 1936, 1942–43, 1948–49, 1956–57, and 1959. In the present study, the relative susceptibility of trees has been studied during the last three substantial storms. The first of these (fig. 3), occurred in the winter of 1942–43 in the St. Lawrence, Mohawk, and Hudson River valleys. In this storm ice accumulation varied from zero to one inch in thickness.

A similar storm December 31, 1948 to January 5, 1949 centered mainly in eastern New York (fig. 4). This storm, studied in great detail, provided gradients of zero to 2 inches in ice thickness. It began as a pre-frontal rain, freezing upon contact, and eventually changed into a snow storm.

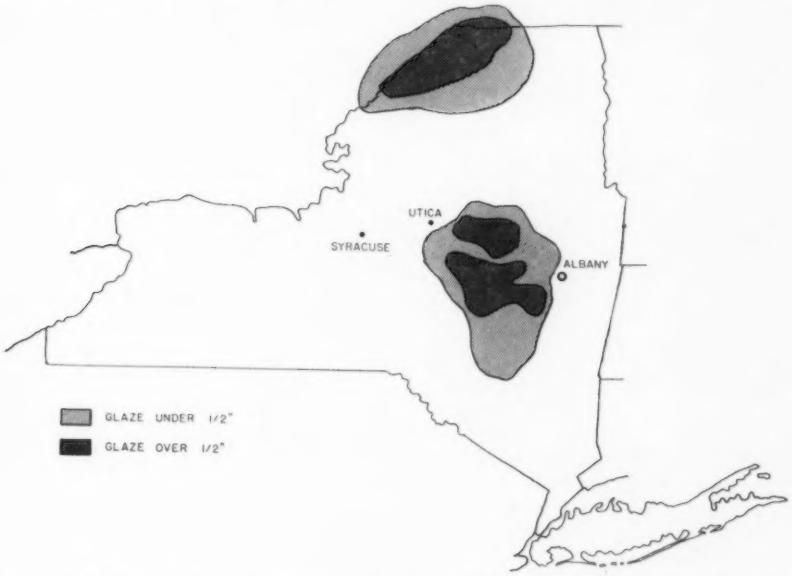

FIG. 3. Map of glaze storm area, eastern New York State, storm of 1942–43.

Other storms gave additional data, particularly those of January, 1950, and February and December of 1956.

Types of breakage. It must be accepted that glaze is a recurring feature in the natural environment of most deciduous forest areas. When ice layers reach one-fourth to one-half inch thickness there is conspicuous breakage in the smaller branches of shrubs and trees. At first it is confined to faulty limbs, more or less in the process of natural pruning. A moderate ice deposit accompanied by strong winds gives results similar to a heavier deposit with gentle winds. Usually, ice one-half to one inch thick will cause conspicuous breakage. With this burden many healthy young branches and young well-formed trees will be broken across their boles.

The amount of ice carried is roughly proportional to the surface area of a tree in winter condition, e. g. as shown in white pine* in fig 5. In this respect *Pinus* spp., *Juniperus virginiana*, *Thuja occidentalis*, and in fact all evergreen gymnosperms are at a disadvantage. The reason is that the foliage offers a large surface area not supported by sufficiently strong branches. Medium sized branches, as a rule, have more strength in proportion to surface area than extremely large or extremely small branches. Rogers (1923) reported that twigs often acquire an ice load 30 times the original twig weight. Von Schrenk (1900) reported limbs 10 times their normal size. Bennett (1959) provided an extensive compilation and review of glaze storms and glaze damage data, including nearly all parts of the world.

FIG. 4. Map of glaze storm area, eastern New York State, storm of 1948–49.

Glaze breakage is not simply a function of ice weight. The arrangement of branches and the strength of live wood also have much to do with the amount of damage to be expected. Windirsch (1936) considers that cylindric crowns are more resistant than conical crowns. Actually, no two species have exactly the same form. It would seem that a very straight and strong central trunk with small flexible side branches might be resistant. *Picea* spp., *Abies balsamea* (L.) Mill, and *Liriodendron tulipifera* have this pattern, and are relatively resistant.

* Common and scientific names of trees mentioned appear in Table I, or in the text if not included in the listings of this table.

One of the best techniques for assessing relative resistance was to find pairs of trees of approximately equal age and size and standing close to each other. Figure 6 shows such an example. Table 1 is an arrangement of

FIG. 5. Glaze coating on foliage of *Pinus strobus* January 3, 1949, near Nassau, New York.

trees studied into three classes of vulnerability. Usually when there is serious damage the trees suffer severe pruning of the major branches. Large limbs ordinarily break before the main trunk yields. The following

species were severed completely across the trunk: aspen, gray birch, American beech, and white pine. These simply died from loss of buds and foliage. Elms sometimes died a year or two later, even though the main trunk was not broken, because their twigs were mainly destroyed and had been made an easy entry for parasites and disease.

Inspection of Table 1 will reveal that the order of relative susceptibility does not strictly follow the increasing order of green wood strength, as listed in the second column. The average for the "very susceptible" group is 6,260 pounds per square inch (p. s. i.), if butternut be excluded. The "resistant" group averages 8,675 p. s. i. However, within each group there

FIG. 6. Paired trees for determing relative susceptibility to glaze damage. *Tilia americana* on left and *Acer saccharum*. Photograph taken March 1, 1949, near Nassau, New York.

is wide variation and there are overlappings between groups. This situation further illustrates that the manner of branching and the angles of attachment interact to make a complex problem. Attachment at a 90 degree angle develops maximum stress whereas an acute angle reduces stress by taking the weight partly endwise.

Effects on crown form. Deformation or "set" is the permanent bending resulting from a tree's inability to regain its original form after carrying an ice burden. Examples of trees that show permanent "set" are: gray

birch, red cedar, cherry (*Prunus* spp.), and willow (*Salix* spp.). These species are often asymmetrical before a storm strikes and hence bend low when extra weight is added. Under heavy ice or snow almost all stems of young even-aged spindly trees will "lodge" like a storm-swept grain field. Later such trunks will grow in a curved, ascending form which is much less erect than before.

Although each tree presents an individual problem, there is sometimes a tendency for a few large side branches on one side to break, making for asymmetry. Thus elms, sugar maple, and basswood become unbalanced frequently. In the Columbia River Gorge another source of asymmetry is the directional nature of glaze storms (Lawrence, 1939). Any process causing

TABLE I. *Classes of glaze damage: susceptibility of common northeastern trees*

Susceptibility Groups and Species	Modulus of Rupture*	
	Green	Seasoned
I. Very Susceptible to Damage		
American Elm (*Ulmus americana* L.)	7,200	11,800
American Basswood (*Tilia americana* L.)	5,000	8,700
Butternut (*Juglans cinerea* L.)	970	1,180
Eastern Cottonwood (*Populus deltoides* Marsh.)	5,300	8,500
Silver Maple (*Acer saccharinum* L.)	5,800	8,900
Black Cherry (*Prunus serotina* Ehrh.)	8,000	12,300
II. Moderately Susceptible to Damage		
Sugar Maple (*Acer saccharum* Marsh.)	9,400	15,800
American Beech (*Fagus grandiflora* Ehrh.)	8,600	14,900
Eastern White Pine (*Pinus strobus* L.)	4,900	8,600
Eastern Hemlock (*Tsuga canadensis* (L.) Carr.)	6,400	8,900
Gray Birch (*Betula populifolia* Marsh.)	——	——
Yellow-poplar (*Liriodendron tulipifera* L.)	6,000	10,100
Quaking Aspen (*Populus tremuloides* Marsh.)	5,100	8,400
Northern Red Oak (*Quercus rubra* L.)	8,300	14,300
III. Resistant to Damage		
White Ash (*Fraxinus americana* L.)	9,600	15,400
Shagbark (*Carya ovata* (Mill.) K. Koch)	11,000	20,200
Red Spruce (*Picea rubens* Sarg.)	5,800	10,200
Yellow Birch (*Betula alleghaniensis* Britt.)	8,300	16,600

* Pounds per square inch for 2 × 2 inch clear timbers (U.S. Forest Service, 1955)

unbalance ill fits a tree to withstand future stresses such as wind or glaze weight.

If, on the other hand, breakage is more symmetrical there may be a narrowing of the tree crown. In the case of American elm, severe storms cause breakage of some of the main horizontal branches, thereby producing a much more compact crown. This contrasts with the wide-spread "umbrella" or "wineglass" form which is typical of undamaged trees of this species. Willow, cottonwood, and possibly basswood provide other examples of this general narrowing. The mechanism is simply that vertical or ascending branches take the weight partly in longitudinal direction and can consequently carry the load better. The wood is apparently able to stand

compression strain better than shearing strain, in this sort of a situation.

Ecological effects. Naturally, this problem depends upon the relative glaze resistance of different species (table 1). All of the "Resistant" group are participants in the northeastern climax forests. Oaks are of moderate resistance, in about the same degree as sugar maple or beech. White pine sometimes suffers breakage but since its whorls have several branches the damage is usually survived. Hemlock seems to be flexible enough to avoid serious damage, especially the younger trees.

Most of the dominant species of the deciduous forest climax seem to

FIG. 7. *Pinus strobus* stem section showing thick growth layers during the 6 years (1943–1948) as a result of release, from glaze pruning in the canopy.

suffer about equally, and typically only moderate damage. Basswood and butternut are at a definite disadvantage where glaze storms are frequent. Downs (1938) found that black cherry was often very aggressive in second growth forests. It is very susceptible, though, and he found that frequent heavy storms above 2,000 feet elevation assisted in the replacement of black cherry by sugar maple and beech. Thus, where sugar maple and beech are climax dominants, succession may be materially aided.

Several species belonging to early successional stages are subject to

severe glaze damage: elms, birches, and several species of *Populus*. Their susceptibility assists in the replacement process and therefore accelerates succession. Gray birch typically bends in a sweeping arc and when the ice melts the trunk straightens somewhat but usually remains deformed. One example of release of an understory species was investigated. This particular area had had a continuous canopy of red maple, sugar maple, and beech. In the rather dense shade, small white pines grew very slowly. A severe glaze storm in 1942–43 pruned the dominant hardwoods and allowed more light to reach the white pine saplings. In 1949 several were cut for study, one of which is shown in fig. 7. These sections showed rapid growth in 1943 and through the years immediately following.

Applications. The responses of forest trees to glaze is yet an additional factor to be taken into account in planning silviculture. Setting aside the differences in species, Illick (1916) found that unsymmetrical trees have uneven stresses and break more easily. When trees are more uniformly spaced the crowns grow in balanced, concentric pattern. Also, there is probably some advantage in the mutual support that closely spaced trees provide. Isolated trees suffer more breakage than those in the more closed stand. This seems to emphasize the wisdom of working toward a fully stocked forest, as Downs (1943) and Hough (1959) recommended.

Literature Cited

Bennett, Iven. 1959. Glaze—its meteorology and climatology, geographical distribution, and economic effects. Quartermaster Research and Engineering Center. Environmental Protection Research Division. Natick, Mass. Technical Report EP-105. i–viii, 1–217.

Christie, E. J. and **H. S. Chartier.** 1943. Glaze storms and electrical service. Electrical Engineering **62:** 431–435.

Downs, A. A. 1938. Glaze damage in the Birch-Beech-Maple-Hemlock type of Pennsylvania and New York. Jour. For. **36:** 63–70.

———. 1943. Minimizing glaze damage in pine. Appalachian Forest Expt. Sta. Tech. Note No. 55 (Processed). 1–5.

Hough, A. F. 1959. Zoning for the management of black cherry on the Allegheny Plateau. Jour. For. **57:** 353–357.

Illick, J. S. 1916. A destructive snow and ice storm. Forest Leaves **15:** 103–107.

Lawrence, Donald B. 1939. Some features of the vegetation of the Columbia River Gorge with special reference to asymmetry in forest trees. Ecol. Monogr. **9:** 217–257.

National Bureau of Standards. 1948. National electrical safety code. National Bureau of Standards Handbook H30. U. S. Gov. Printing Office. 161–168.

Rogers, W. E. 1923. Resistance of trees to ice-storm injury. Torreya **23:** 95–99.

Talman, Charles F. 1931. The realm of the air. Bobbs-Merrill Co. Indianapolis. 1–318.

United States Forest Servcie. 1955. Wood Handbook. United States Department of Agriculture. Agriculture Handbook No. 72. 67–104.

Von Schrenk, H. 1900. A severe sleet-storm. Trans. Acad. of Science of St. Louis. **10:** 143–160.

Windirsch, J. 1936. Der Aufbau des Waldbaumes nach statischer Grundlage. Tharandter Forstl. Jahrb. **87:** 533–566.

BULLETIN OF THE TORREY BOTANICAL CLUB

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The radiosensitivity of two species of *Nicotiana* and of their interspecific hybrid[1]

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ABSTRACT

MEISELMAN, NEWTON, ARNOLD H. SPARROW, and JAMES E. GUNCKEL. (Brookhaven Natl. Lab., Upton, N. Y. and Rutgers U., New Brunswick, N. J.). The radiosensitivity of two species of *Nicotiana* and of their interspecific hybrid. Bull. Torrey Bot. Club 88(1): 30–38. Illus. 1961.—Two species of tobacco, *Nicotiana bigelovii* and *N. glauca*, and their hybrid were exposed to various dose rates of chronic gamma irradiation (37.5–375 r per day) from cobalt-60 for periods up to 39 days. Within a species, chromosomal aberration frequency at a particular dose rate showed no significant increase in successive collections from 15 to 39 days of exposure. Differences in the amount of chromosomal aberration between stocks were evident for plants at the various dose rates as well as in the controls (unirradiated). Bridges and fragments were found to occur with a 38 per cent frequency in the hybrid controls, but none were found in the control samples of the parental stocks. Under chronic irradiation, *N. glauca* was the least sensitive, *N. bigelovii* was next, and the hybrid was the most sensitive. In the hybrid, aberrations may differ in mode of origin from those of the two parental species, as indicated by a disparity in the fragment to bridge ratio and by the presence of configurations suggesting subchromatid exchange. Computations based upon the total percentage aberration at each dose rate for the three plant stocks were used to calculate regression lines. The slope of the regression line for *N. glauca* ($2x = 24$) was 0.087 aberrations per 100 cells per r; for *N. bigelovii* ($4x = 48$), 0.168; and for *N. bigelovii* × *N. glauca* ($3x = 36$), 0.326. The hybrid, then did not fall between the two parents as might be expected but had an increased aberration rate about four times that of *N. glauca* and about twice the expected. Since the increase in radiation sensitivity of the hybrid cannot be explained on the basis of relative chromosome number, it is concluded that its increased radiosensitivity must be related to the inherent nature of its genetic instability or to its reduced growth rate.

Certain interspecific hybrids of the genus *Nicotiana* have been found to exhibit spontaneous chromosomal abnormalities (Kostoff, 1943). One such interspecific hybrid, *Nicotiana bigelovii* Torrey × *N. glauca* Graham (McCray, 1932; Kehr and Smith, 1952; Goodspeed, 1954) has been used in the present experiment. The possibility of a causal relationship between spontaneously occurring chromosomal bridges and certain morphological

[1] Research carried out in part at Rutgers—the State University under A.E.C. contract no. AT(30–1)–1120, and with the cooperation of the University Research Council, and in part at the Brookhaven National Laboratory under the auspices of the U. S. Atomic Energy Commission. Grateful appreciation is extended to Dr. Phelps Crump, biometrician to the Brookhaven Biology Department, for assistance with statistical analyses.

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aberrations (such as the leaf margin distortions noted originally by McCray, 1932 suggested that this hybrid and its parents might be particularly interesting ones to use in a study of the factors determining radiosensitivity in plants. Since the normal frequency of spontaneous variants was high, it was thought that subjecting these plants to chronic gamma irradiation might tend to exaggerate these conditions and perhaps make quantitative determinations of any changes much easier. Specifically, we hoped to determine whether the frequently aberrant hybrid would show any increase in sensitivity to radiation over its parental species, to look for a relationship between sensitivity and number of chromosomes, and to try to correlate the frequency of induced chromosomal aberrations with the degree of morphological abnormality observed.

MATERIALS AND METHODS. Chronic gamma irradiation of two species of tobacco, *Nicotiana bigelovii* var. *quadrivalvis* (4x = 48) and *N. glauca* (2x = 24) and the F_1 hybrid, *N. bigelovii* × *N. glauca* (3x = 36), was carried out in the Brookhaven National Laboratory "gamma field" facility during the summers of 1954 and 1955. Seedlings of the two parental species, 10–13 cm. in height, were transplanted from the greenhouse to the gamma field in June, along with rooted hybrid cuttings. The hybrid cuttings were a clonal line derived from a field-grown plant. The plants were irradiated 20 hrs/day with gamma rays from a cobalt-60 source according to the methods outlined elsewhere (Meiselman et al, 1961; see also Sparrow and Singleton, 1953; Sparrow, 1960). They were exposed at six radiation intensities, ranging from 37.5 to 375 r per day (table 1), and collections for cytological analysis were made after 15, 21 and 39 days of exposure to radiation.

The tips of vigorously growing young shoots were removed from the irradiated plants, dissected under a microscope, and fixed in 3:1 alcohol-acetic acid. Leaves about 2 mm. in length were selected for cytological study. They were stained by the standard Feulgen techninque, squashed and macerated on slides in 45 per cent acetic acid, quick frozen on dry ice by the method of Conger and Fairchild (1953), dehydrated in alcohol and mounted in Euparal.

The cells used for analysis were those in either anaphase or early telophase (table 1).

RESULTS. Since anaphase and telophase bridges and acentric fragments were the most common types of chromosomal aberrations found in our material, they were used as an index of radiation-induced cytological damage.

No spontaneous bridges were found in 184 cells of the *N. glauca* controls or in 117 cells in the *N. bigelovii* controls. No fragments were found in the control sample of cells of either parent. While neither fragments nor bridges were found in the samples of cells counted some do occur spontaneously and

TABLE 1. *Numbers of chromosomal aberrations in control and irradiated young leaves of* ***N. glauca, N. bigelovii*** *and* ***N. bigelovii*** × ***N. glauca.***

Dose rate (r/day)	Total no. analyzed cells	Total no. of bridges	Total no. of frags.	Average no. of induced aberrations per 100 cells*	
N. glauca					
Control	184	0	0	0	
37.5	148	0	0	0	
75	162	0	5	3	
150	182	8	4	7	
225	106	12	6	17	
300	64	3	11	22	
375	131	33	13	35	
Total	977	56	39		
N. bigelovii					
Control	117	0	0	0	
37.5	128	2	2	3	
75	78	2	3	6	
150	102	14	7	21	
225	145	20	15	24	
300	123	34	18	42	
375	28	12	6	64	
Total	721	84	51		Corr. **
N. bigelovii × ***N. glauca***					
Control	124	40	7	38	0
37.5	74	20	9	39	1
75	118	66	13	67	29
150	196	121	15	70	32
225	97	104	16	124	86
300	166	184	26	127	89
375	—	—	—	—	—
Total	775	535	86		

* These values are derived from the sums of bridges and fragments.

** Average number of induced aberrations per 100 cells corrected for spontaneous rate found in controls, i.e., 124 cells scored had 40 bridges and 7 fragments or 38 aberrations per 100 cells.

a few were seen in cells not scored. The rate, however, is very low, probably well below 1%. The hybrid had a very high spontaneous aberration rate, 32 bridges and 6 acentric fragments per 100 cells. This spontaneous aberration rate, 38 per cent (32 bridges plus 6 fragments per 100 cells), was subtracted from the observed rate at each dose to obtain the induced rate.

Cells were frequently scored at very late anaphase or telophase in which the remains of dicentric bridges were still evident. In some cases the long arms extended from each daughter nucleus to the point where a cell wall was forming. In other cases the cell wall was not evident and thin strands extended toward each other from the opposite chromosome clusters.

The chromosomes of the parental type, *N. glauca,* are less sensitive to chronic irradiation than those in either of the other two lines as can be seen

from table 1 and fig. 1. It required relatively high dose rates (150–225 r per day) to produce cytological aberrations in appreciable numbers. The overall fragment to bridge ratio was 0.70 (39 : 56). Single and double bridges occurred in about equal numbers, beginning to appear at the dose rate of 150 r per day, and continuing through the higher dose rates.

The other parental type, *N. bigelovii*, was slightly more sensitive to radiation than *N. glauca*. The proportion of fragments to bridges was lower (0.61 or 51 : 84), and noticeable effects were evident in the intensity range of 75–150 r per day. The total number of aberrations per 100 cells at the

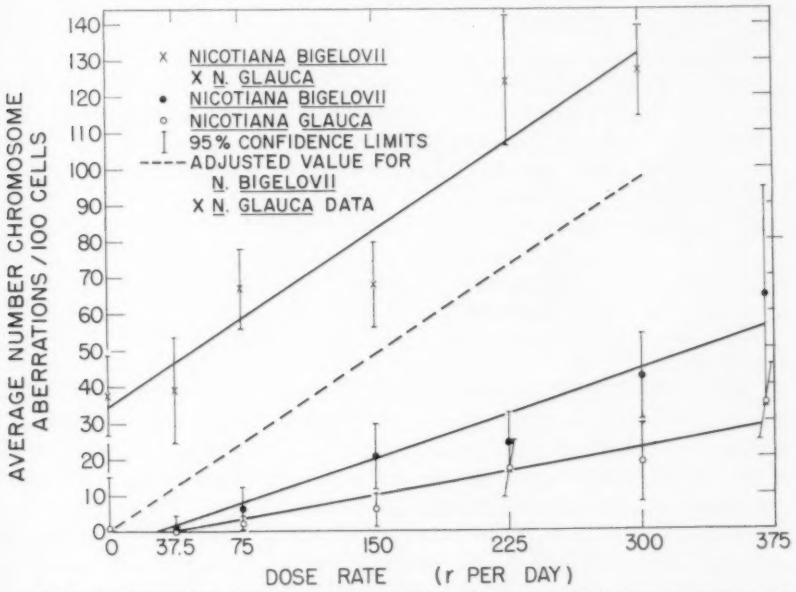

Fig. 1. Regressions showing average number of chromosomal aberrations per 100 cells with increasing dose rate in somatic tissue of two species of *Nicotiana* and their interspecific hybrid. The dotted line is the adjusted value for the hybrid obtained by subtracting the aberration value observed in control hybrid plants from that observed in the irradiated hybrid plants.

higher dosages was just about twice that in *N. glauca* (see fig. 1). Single bridges occurred with slightly greater frequency than double bridges and, beginning at 150 r per day, some multiple bridges were evident.

In the hybrid there was more variability in the radiation response from plant to plant than in the two parents and there was clearly a higher level of sensitivity since chromosomal aberrations appeared at 75 r per day in very large numbers. Further, the average number of bridges and fragments per cell was nearly four times that found in the *N. glauca* parent. The ratio

of fragments to bridges was far lower in the hybrid, being only 0.16 (86 : 535), while for *N. bigelovii* it was 0.61 (51 : 84) and for *N. glauca* 0.70 (39 : 56). In the hybrid, nearly equal numbers of single, double and multiple bridges occurred.

Regression lines were calculated by the method of least squares from the data in the column of table 1 marked "Average number of induced aberrations per 100 cells." The slope of the regression line for *N. glauca*, with a somatic number of 24 chromosomes, is about one-half the slope of the line for *N. bigelovii*, with a somatic chromosome number of 48. The calculated slopes are 0.087 chromosome aberrations per 100 cells per r for *N. glauca* and 0.168 in the same ratio for *N. bigelovii* (fig. 1). The hybrid has a somatic chromosome number of 36, with 24 chromosomes contributed by the maternal parent (*N. bigelovii*) and 12 by the paternal (*N. glauca*). This falls midway between the diploid chromosome numbers of the parent stocks. If the aberration frequency were dependent solely upon chromosome number, one might expect that its regression line would be intermediate between the two parents. However, the regression line for *N. bigelovii* × *N. glauca* has a slope of 0.326, or approximately 2.6 times this hypothetical intermediate slope. In all cases the differences in the slopes were statistically significant. Thus, the data relating to the chromosome radiosensitivity of the hybrid compared to its parents showed no evidence of any direct relationship between chromosome number and the number of chromosomal aberrations.

DISCUSSION. Spontaneously occurring mitotic and meiotic aberrations in many plant species have been extensively described in the literature. These have been described as being due to physiological "stickiness" of the chromosomes, "breakage-fusion-bridge" cycles, or simply to factors introduced by hybridity in interspecific crosses.

McCray (1932) was the first to describe the hybrid resulting from the cross of *Nicotiana bigelovii* × *N. glauca*. He noted that there was a lack of uniformity in the F_1 plants and that practically all leaf characters were different from the parents. These and other growth irregularities were later noted by Kostoff (1943), Kehr and Smith (1952), and Goodspeed (1954), as well as in the present study (Meiselman, et al, 1961).

Chromosomal irregularities in somatic cells in the F_1 hybrid (Kehr, personal communication) and bridges at meiotic anaphases of the amphidiploid of the hybrid are characteristically found in non-irradiated plants (Kostoff, 1943; Goodspeed, 1954). Kostoff (1940) found one plant of *Nicotiana glauca* × *N. langsdorffii* in which almost 20 per cent of the root tip mitoses were abnormal (the lowest rate found was about 4.2 per cent of abnormal anaphases). Similarly, in the *N. bigelovii* × *N. glauca* hybrid, the present authors found a spontaneous rate of 32 per cent bridges and 6 per cent fragments in somatic cells.

In the cells of the hybrid, *N. bigelovii* × *N. glauca*, there are not only bridges and fragments, but there is also some chromosome lagging during anaphase and a tendency toward "stickiness" or delayed separation of the chromosomes. Although the authors recognize that some of the bridges in the hybrid cells may result from "stickiness" (e.g., see Catcheside, 1948; Darlington and LaCour, 1945; Marquardt, 1938; Swanson, 1957), the linear relationship obtained with increasing radiation intensities indicates that genuine radiation-induced bridging also occurs.

The fact that hybridity might be a factor in producing these spontaneous chromosome bridges has been suggested by several investigators working with different plant genera. Plotnikowa (1932) observed a high frequency of chromatid bridges and fragments in root tip mitoses of an intergeneric cross of *Triticum* and *Secale*. Giles (1940) also found that the frequency of spontaneous chromosome breaks in microspore nuclei of a *Tradescantia* species hybrid was about three times as high as in the pure species examined. Brock (1954) noted that spontaneous chromosome breakages produced dicentrics, rings, bridges and fragments in the endosperm of *Lilium regale* and of a lily hybrid. He suggested that the original abnormalities probably form a certain number of dicentrics and that these could form bridges at anaphase where further chromosome breakage and reunion can occur. McClintock (1942, 1943) working with chromosome 9 of *Zea mays* has shown that after the establishment of two contiguous dicentric chromatin bridges this type of aberration can be self-perpetuating by the breakage-fusion-bridge cycle, both in gametophytic and sporophytic tissue.

If each original bridge in our material survived for a number of cell generations by means of a breakage-fusion-bridge cycle, one would expect a great preponderance of bridges over fragments. Since this was true only in the hybrid, it seems possible that the origin and/or survival of bridges may be different in the hybrid than in the parental lines, at least in irradiated material. However, we have no evidence bearing directly on this point. One can speculate, however, that physiological disturbances which apparently exist in the hybrid and not in the parental lines may facilitate the production and/or maintenance of certain chromosomal conditions. These might include a greater incidence of subchromatid exchanges (as seen in the hybrid by us and in other plants by Brock, 1955; Walters, 1955; and Wilson, Sparrow and Pond, 1959) perhaps facilitated by "stickiness" and/or survival through several cell generations of bridges, once formed, through a breakage-fusion-bridge mechanism. Either of these mechanisms would lead to a low fragment/bridge ratio as shown in our data. Many factors are listed by Gunckel and Sparrow (in press) as possible determiners of the radiosensitivity of a given species. They found that species with large chromosomes have high radiosensitivities, while those with smaller chromosomes tend to be less sensitive (Sparrow and Gunckel, 1956). Polyploid species

within a genus tend to be less sensitive than diploid species (Sparrow and Schairer, 1958). Since little or no difference in chromosome size was apparent between the three lines studied, chromosome size was not, presumably, a significant factor in our experiments. Chromosome number, however, will be considered more fully below.

The work of Sax and Swanson (1941) indicated that in *Tradescantia* there is a lower chromosome sensitivity in microspores of a tetraploid species than in a corresponding diploid. In contrast, Bishop (1952) found that the differential sensitivity of chromosomes in *Tradescantia* depended upon the stage during which the cell was irradiated, and that a comparison of cells of each stage and the types of aberration produced showed that the difference in frequency of aberration in diploid and tetraploid cells was proportional to differences in the chromosome number. Conger (1956), also working with *Tradescantia*, compared haploid and diploid microspores and drew a similar conclusion. Smith (1943) found that the incidence of radiation-induced translocations in wheat was approximately proportional to chromosome number in diploid, tetraploid and hexaploid species. In a similar study, Natarajan, Sikka and Swaminathan (1958) found that the frequency of chromosome aberration induced by X rays is proportional to total chromosome length in diploid, tetraploid and hexaploid species. In our study, the slope of regression lines representing the average chromosomal aberrations for each species showed that the hybrid (3x) had a significantly higher degree of sensitivity than was exhibited by either the 2x or 4x parental species. When the chromosomal aberration rates of the three stocks under irradiation were compared on a per chromosome basis, those of the two parent stocks coincided while that of the hybrid was considerably higher. The increased sensitivity of the hybrid is not due, then, to the chromosome number, but is presumably due to unknown factors inherent in the hybrid.

One possible explanation for the higher rate of induced breakage in the hybrid could be a slower rate of growth. If the average duration of a whole nuclear cycle were prolonged in the hybrid each nucleus would be exposed to a greater cumulative dose before entering mitosis. This could result in a higher incidence of chromosome breakage than would occur in the parental stocks if they grew at a faster rate than the hybrid. Unpublished observations on other plants indicate that growth rate may be an important factor in determining the tolerance of chronically irradiated plants.

LITERATURE CITED

Bishop, C. J. 1952. The influence of polyploidy on the X-ray sensitivity of cells. Canad. Jour. Bot. **30**: 139-146.

Brock, R. D. 1954. Spontaneous chromosome breakage in *Lilium* endosperm. Ann. Bot. **18**: 7–14.

———. 1955. Chromosome balance and endosperm failure in hyacinths. Heredity **9**: 199–222.

Catcheside, D. G. 1948. Genetic effects of radiations. *In* Advances in Genetics, ed. by M. Demerec. Academic Press, Inc., New York.

Conger, A. D. 1956. Polyploidy and radiosensitivity. Nature **178:** 271.

————, and **L. M. Fairchild.** 1953. A quick-freeze method for making smear slides permanent. Stain Tech. **28:** 281–283.

Darlington, C. D. and **L. LaCour.** 1945. Chromosome breakage and the nucleic acid cycle. Jour. Genetics **46:** 180–267.

Giles, N. H. 1940. Spontaneous chromosome aberrations in *Tradescantia*. Genetics **25:** 69–87.

Goodspeed, T. H. 1954. The genus *Nicotiana*. Chronica Botanica. Waltham, Massachusetts. 536 p.

Gunckel, J. E., and **A. H. Sparrow.** 1961. Ionizing radiations: biochemical, physiological and morphological aspects of their effects on plants. Encyclopedia of Plant Physiol. Springer-Verlag, Heidelberg. **16:** (in press).

Kehr, A. E., and **H. H. Smith.** 1952. Multiple genome relationships in *Nicotiana*. Memoir 311, Cornell Univ. Agric. Expt. Sta. Ithaca, New York.

Kostoff, D. 1940. Studies on atypical growth in plants from a cytogenetic point of view. Jour. Genetics **39:** 469–484.

————. 1943. Cytogenetics of the genus *Nicotiana*. States Printing House, Sofia. 1073 p.

Marquardt, H. 1938. Die Röntgenpathologie der Mitose. Zeitschr. Bot. **32:** 401–482.

McClintock, Barbara. 1942. The behavior of "unsaturated" broken ends of chromosomes. Year Book Carnegie Inst. Wash. (D.C.) **41:** 181–183.

————. 1943. Studies with broken chromosomes. Year Book Carnegie Inst. Wash. (D.C.) **42:** 148–150.

McCray, F. A. 1932. Compatibility of certain *Nicotiana* species. Genetics **17:** 621–636.

Meiselman, N., J. E. Gunckel, and **A. H. Sparrow.** 1961. The general morphology and growth responses of two species of *Nicotiana* and their interspecific hybrid after chronic gamma irradiation. Radiation Bot. (in press).

Natarajan, A. T., S. M. Sikka, and **M. S. Swaminathan.** 1958. Polyploidy, radiosensitivity and mutation frequency in wheats. Proc. Internat. Conf. on Peaceful Uses of Atomic Energy, 2nd Conf., Geneva, **27:** 321–331.

Plotnikowa, T. W. 1932. Zytologische Untersuchung der Weizen-Roggen-Bastarde. I. Abnormale Kernteilung in somatischen Zellen. Planta **16:** 174–177.

Sax, K., and **C. P. Swanson.** 1941. Differential sensitivity of cells to X rays. Amer. Jour. Bot. **28:** 52–59.

Smith, L. 1943. Relation of polyploidy to heat and X-ray effects in the cereals. Jour. Heredity **34:** 130–134.

Sparrow, A. H. 1960. Uses of large sources of ionizing radiation in botanical research and some possible practical applications. In Large Radiation Sources in Industry. Internat. Atomic Energy Agency, Vienna. **2:** 195–219.

————, and **J. E. Gunckel.** 1956. The effects in plants of chronic exposure to gamma radiation from radio-cobalt. Proc. Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva, **12:** 52–59.

————, and **L. A. Schairer.** 1958. Some factors influencing radioresistance and tumor induction in plants. Proc. Internat. Conf. on Peaceful Uses of Atomic Energy, 2nd Conf., Geneva, **27:** 335–340.

————, and **W. R. Singleton.** 1953. The use of radiocobalt as a source of gamma rays and some effects of chronic irradiation on growing plants. Amer. Nat. **87:** 29–48.

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Swanson, C. 1957. Cytology and Cytogenetics. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 596 p.

Walters, Marta S. 1955. A study of half-chromatid fragments in meiosis of the hybrid *Bromus trinii* × *B. maritimus*. Univ. of Calif. Publ. in Bot. **28**: 1–18.

Wilson, G. B., A. H. Sparrow, and **Virginia Pond.** 1959. Sub-chromatid rearrangements in *Trillium erectum* L. I. Origin and nature of configurations induced by ionizing radiation. Amer. Jour. Bot. **46**: 309–316.

Influencing yeast growth with hydrogen peroxide

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ABSTRACT

TOWNSEND G. FRED. (Wahl-Henius Inst., Chicago.) Influencing yeast growth with hydrogen peroxide. Bull. Torrey Bot. Club 88(1): 38–42. Illus. 1961.—An inoculum of *Saccharomyces cerevisiae* was suspended in M/15 KH_2PO_4. After 12 hr cells were removed and exposed to 3% H_2O_2 for 60 min at 23°C. These cells were subsequently cultured in growth medium, with or without agar. There was a greater tendency toward production of larger spherical cells and/or chains. Budding delay and nonsynchrony increased. No tube shaped or dumb-bell shaped cells appeared.

In almost any culture of *Saccharomyces cerevisiae*, occasional cells may be encountered which exhibit various budding irregularities, or which have become spherical, or enlarged, or arranged in chains. By means of controlled exposure of a yeast population to hydrogen peroxide, many such departures from normal growth patterns may be found emphasized when the exposed cells are cultured.

Procedure. Fresh baker's yeast, a strain of *Saccharomyces cerevisiae*, was mixed with enough tap water to form a thick suspension and then introduced into an excess of M/15 monopotassium phosphate. After 12 hours, portions of this stock were removed and centrifuged. The cells were suspended in a large volume of 3% hydrogen peroxide for 60 minutes at 23°C, then diluted with an equal part of water and recentrifuged. Finally they were rinsed with tap water and inoculated into a nutrient of glucose 2%, monoammonium phosphate 1%, yeast extract 1%, peptone 1%, and monopotassium phosphate 0.2%, either with or without agar. The liquid culture was fermented without agitation in a loosely stoppered flask and the agar culture was grown on a slide covered with a thin cover slip, the entire mount being kept moist in a closed Petri dish containing a dampened blotter. Incubation temperature for both preparations was 23°C.

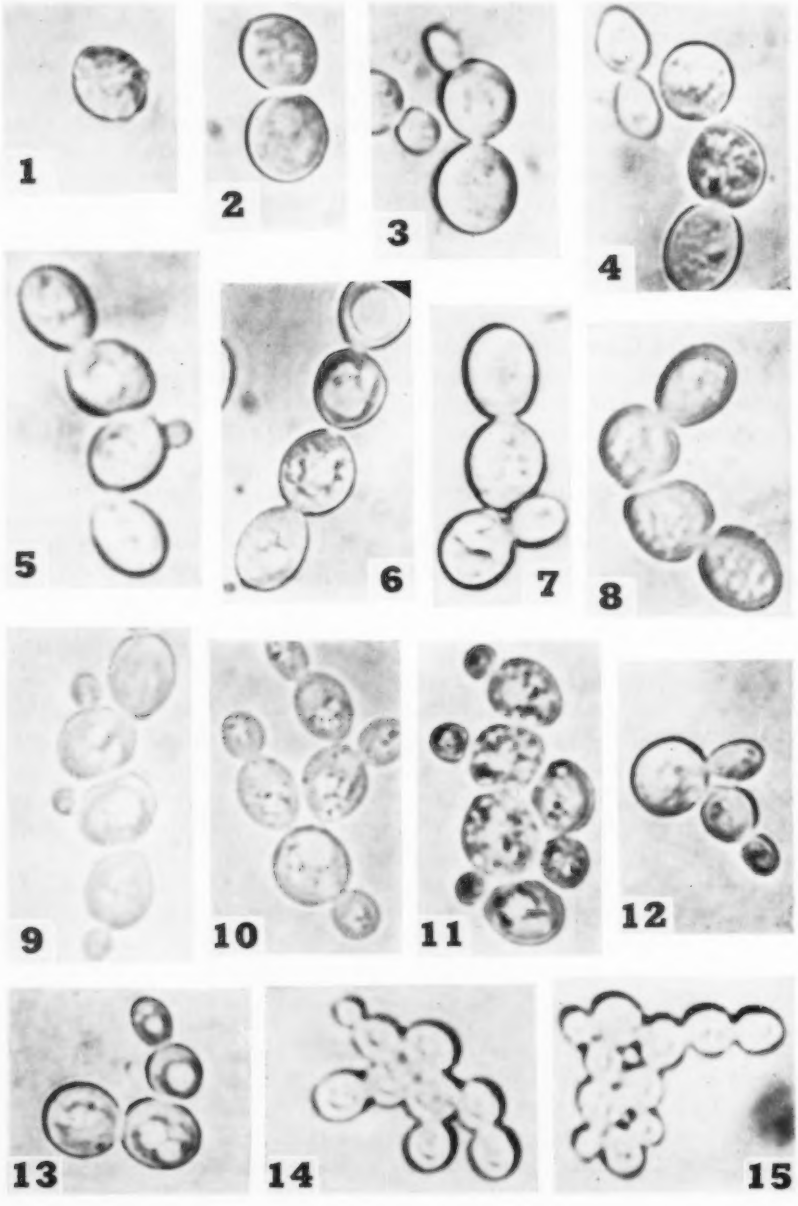
Observations. The response of individuals of the yeast population is variable. Some cells are apparently unaffected by contact with the hydrogen peroxide, or if they are affected, they soon recover, as in the case of the

smaller cells in fig. 4. At the other extreme, some of those affected by the exposure seem never to return to normal size, shape, or budding activity. Still other cells may demonstrate varying reactions and recovery patterns. Retarded and/or nonsynchronous budding occurs often as in figs. 3, 5, 11, or 13, and swelling and abnormal rounding of the cells is frequent. In some instances an enlarged cell does not reproduce, fig. 1 shows such a cell still unbudded after 60 hours. At other times it will bud once (perhaps by way of a small initial bud) whereupon both cells may become of equal size and remain connected (fig. 2). A 6–8 hour culture usually has a large number of cell pairs. If further budding then occurs, it may or may not be delayed and spherical cells will often arise simultaneously at opposite ends of the pair, forming a chain of four cells (fig. 6). Many of these are found after 8½–10 hours. If budding of one of the paired cells is arrested or materially delayed, a row of three cells can arise (see larger cells in fig. 4). These multiple cell arrangements usually occur as two's or four's, however they have been found with odd or even numbers up to eight.

These series are quite flexible but the cells tend to cling together at the points of attachment. It is not unusual to find two cells at one end of a chain aligned across and at a sharp angle with the longitudinal axis of the chain (figs. 7, 8). This condition may be brought about when the end cell or the cell next to the end puts out a bud toward one side, and the bud develops to full size. This bud often projects originally at an angle of about 60° or 120°. It may however become crowded as growth proceeds and with the end cell swing around to a position almost at right angles with the group. The chains may possibly discontinue budding (figs. 4, 6, 8) or they may show further even or uneven rebudding (figs. 5, 7, 9, 11). Probably however, only a few more generations will arise from any one of the cells, and at best only a small colony of these larger cells will generally develop (figs. 14, 15). Then too, it is found that sometimes certain large round cells gradually, or perhaps abruptly, begin producing cells of normal size and shape (figs. 10,12, 13). These in turn behave like the untreated controls.

Other considerations. The hydrogen peroxide produces an effect after a few minutes of contact, but an exposure time of 30 to 60 minutes favors an increase of spherical cells and retards growth of more of the remaining cells, thus the anomalies are not as quickly obscured by overgrowth with the normals.

For example, when the maximum number of original members of an untreated population had developed groups of four full sized cells, about 8% of the population had given rise to straight or slightly curved 4-cell chains (as contrasted with sharply zig zagging chains or clumps). The 60 minute treated population, when examined at its corresponding peak, disclosed that 20% of its original members had produced straight or slightly curved series. Among the 30 minute treated cells, about 15% could be so classified.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Such findings are of greater relative significance when one considers that budding delay and nonsynchrony are increased by lengthened hydrogen peroxide treatement. The "peak" or "maximum" referred to was reached at around 6 hours in the control and involved about 95% of the original population. That same maximum occurred at 8–8½ hours with cells from the 30 minute peroxide treatment and involved, at any time during that period, about 60% of the population. The 60 minute peroxide treatment disrupted normal budding activity to an even greater extent, so that here maximum appearance of 4-cell groups was delayed until 9–10 hours when, at any counting, these could be attributed to approximately 40% of the original population. As might be expected with the more drastic treatment, there were many unbudded single cells, cell pairs, and three membered chains, with 12%, 8%, and 7% respectively, being of typical occurrence. At this time probably less than 20% of the total number of cells were truly ellipsoidal. The control culture displayed 85% ellipsoidal cells at the corresponding stage of development.

It was noted that the peroxide treatment was more effective at 23°C than at 15°C. Subsequent culturing at 18°C or at 15°C gave progressively slower growth and also gave progressively larger numbers of round cells and chains. In fact, the untreated control cells cultured at 14°C showed a growth picture much like that of the peroxide treated cells cultured at the same temperature. There seemed however, a greater tendency for the controls to regain a normal appearance. At lower temperatures all cells were more granular, but this was true of the general population and it did not affect reproduction, other than that the offspring were also more granular (fig. 10 and especially fig. 11). The chains formed were longer retained at these lower temperatures when compared with the higher temperatures and there was less tendency for the spherical cells to become ellipsoidal.

Comments. The growth patterns of hydrogen peroxide treated cultures resemble in some ways those of cultures exposed to radiations of radium as described by Bauch (1944) or of X-rays as described by Brace (1950).

FIGS. 1–15. Cells of *Saccharomyces cerevisiae* which have been exposed to hydrogen peroxide and subcultured. All marginal cells are terminal except top cell of FIG. 9 which has a small bud projecting upward. FIG. 1. Enlarged cell unbudded after 60 hrs. FIG. 2. Enlarged cell pair which has not budded. FIG. 3. Enlarged cell pair with uneven budding. Also budding cell of normal size. FIG. 4. Chain of three large cells and a budding cell of normal size apparently unaffected by hydrogen peroxide treatment. FIG. 5. Chain of four large cells exhibiting nonsynchronous budding. FIG. 6. Chain of four enlarged cells. FIG. 7. Chain of three large cells with nonsynchronous budding at angle with chain. FIG. 8. Chain of four large cells with budding at angle with chain. FIG. 9. Chain of four cells with synchronous budding. FIG. 10. Enlarged cell at lower center with offspring returning to normal size and shape through several generations. FIG. 11. Chain of four large granular cells with nearly synchronuos budding. Succeeding generations retain granular appearance when cultured at 14°–15°C. FIG. 12. Large cell abruptly producing cells of normal size. FIG. 13. Large cell pair with uneven budding, and abrupt return of normal appearing cells within one generation. FIGS. 14, 15. Minute colonies produced by enlarged cells.

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Dumb-bell shaped arrangements and tube shaped cells, which are generally associated with ultraviolet radiation damage (see Townsend and Sarachek, 1953, or Schauz, 1958) were not observed in any of the cultures studied. The development and retention of peroxide induced aberrations was rather enhanced by lowered temperatures. No cases of excessively elongated or filamentous type cells were encountered although some workers have found cell elongation to be increased at reduced incubation temperatures, as discussed by Scherr and Weaver (1953) in their review of dimorphism in yeast.

Consideration of the above observations allows one to assume that the appearance, in cultures of *Saccharomyces cerevisiae*, of a particular budding characteristic which gives rise to tube cells or dumb-bell formations could not be attributed entirely to the presence of hydrogen peroxide in the suspending medium.

Literature Cited

Bauch, R. 1944. Die Erblichkeit der durch Radiumbestrahlung bei der Hefe ausgelosten Riesenzellbildung. Arch. Mikrobiol. **13**: 352–364.

Brace, K. C. 1950. Effects of X-rays on size of yeast cells. Proc. Soc. Exp. Biol. & Med. **74**: 751–755.

Schauz, K. 1958. Untersuchungen uber UV-Resistenz bei *Saccharomyces cerevisiae*. Arch. Mikrobiol. **28**: 349–368.

Scherr, G. H. and Weaver, R. H. 1953. The dimorphism phenomenon in yeasts. Bact. Rev. **17**: 51–92.

Townsend, G. F. and Sarachek, A. 1953. Characteristic alterations of the budding process of *Saccharomyces* induced by ultraviolet treatment. Jour. Bact. **65**: 747–749.

The utilization of nucleic acid derivatives by *Penicillium chrysogenum*

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ABSTRACT

KIM, Y. T. and F. T. WOLF. (Vanderbilt U., Nashville.) The utilization of nucleic acid derivatives by *Penicillium chrysogenum*. Bull. Torrey Bot. Club 88(1): 42–46. 1961.—The utilization of 34 nucleic acid derivatives and related compounds, as sole sources of nitrogen for growth, has been studied in *Penicillium chrysogenum* Q-176. All of the pyramidines tested were either not utilized or proved to be poor sources of nitrogen for growth. The purines adenine, guanine, hypoxanthine, xanthine, and uric acid, as well as allantoin and urea, were excellent nitrogen sources for *P. chrysogenum*. Methylated purines were not utilized. Both ribonucleic acid and deoxyribonucleic acid are favorable nitrogen sources for *P. chrysogenum*. Adenine and guanine are better utilized for growth than are adenosine, adenylic acid, guanosine, or guanylic acid. Cytidine, cytidylic acid, uridine and uridylic acid are utilized more efficiently than are cystosine or uracil.

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The utilization of nucleic acid derivatives and related compounds as nitrogen sources for growth of fungi has been reviewed by Wolf (1953) and more recently by Cochrane (1958). It was found that pyrimidines were very poor sources of nitrogen for growth of *Neurospora sitophila*. While purines were excellent nitrogen sources, methylated purines supported but little growth. Both ribonucleic acid and deoxyribonucleic acid were favorable nitrogen sources. Certain purine and pyrimidine nucleosides and nucleotides (adenosine, adenylic acid, guanosine, guanylic acid, cytidine, cytidylic acid) were utilized more efficiently for growth than the corresponding free bases. Such differences were not found, however, between hypoxanthine and inosine, or between xanthine and xanthosine, all of which were excellent nitrogen sources for growth, nor among uracil, uridine and uridylic acid, which were poor nitrogen sources for this organism (Wolf 1953).

In a subsequent study of *Fusarium oxysporum* var. *nicotianae*, the same general conclusions were reached concerning utilization of pyrimidines, purines and methylated purines. 2, 6-diamino purine, which was not utilized by *Neurospora*, proved to be an excellent nitrogen source for *Fusarium*. No significant differences were found in the utilization of purines, purine nucleosides and purine nucleotides by *Fusarium*. Upon comparison of the pyrimidines, pyrimidine nucleosides and nucleotides, however, it was apparent that the nucleosides were more favorable nitrogen sources than either the free pyrimidines or the nucleotides, and compared favorably with purines as nitrogen sources (Wolf 1955).

It is the purpose of the present paper to report the results of essentially similar studies with the fungus *Penicillium chrysogenum*.

MATERIALS AND METHODS. The fungus studied was an isolate of *Penicillium chrysogenum* Q-176, originally obtained from the Northern Regional Research Laboratory (now Northern Regional Research and Development Division), U. S. Department of Agriculture, Peoria, Illinois. Stock cultures were maintained on slants of Czapek's agar. The basal medium for submerged cultures was adapted from one developed by Moyer and Coghill (1946), and has the following composition: lactose monohydrate, 27.5 gm.; glucose monohydrate, 3.0 gm.; $MgSo_4 \cdot 7H_2O$, 0.25 gm.; KH_2PO_4, 0.50 gm.; $ZnSO_4 \cdot 7H_2O$, 0.044 gm.; and $MnSO_4 \cdot 4H_2O$, 0.020 gm. per liter. To this basal medium were added various nucleic acid derivatives as sole sources of nitrogen, in quantities sufficient to provide a nitrogen concentration of 25 mg. per 100 ml. Controls were included containing no nitrogen, sodium nitrate, or ammonium sulphate, for purposes of comparison.

The sources of the experimental chemicals were, in general, the same as in a previous study (Wolf 1953). Isocytosine and isoguanine sulfate were obtained from Nutritional Biochemicals Inc., Cleveland, Ohio.

The media were dispensed in 50 ml. quantities in 125 ml. Erlenmeyer

flasks. The pH was adjusted to 5.0, and the media were sterilized by autoclaving. The media were inoculated by means of a sterile pipette, with a spore suspension prepared in a sterile water blank. The cultures were grown on a rotary shaker, operated at approximately 100 r. p. m., for 8 days at room temperature. At the end of the incubation period, the mycelia were removed by filtration through pieces of tared filter paper, were washed thoroughly, were dried to constant weight in a desiccator over drierite, and the weights were recorded.

All experiments were done in duplicate, and were replicated four times, so that, in most instances, each value reported is based upon eight cultures. In order to give some indication of the reproducibility of the data, standard deviations were calculated.

RESULTS. The results of the various experiments are presented in Table 1. Nitrate appears to be slightly superior to ammonium as a nitrogen source for *P. chrysogenum*, though the difference is not great, and either is a favorable nitrogen source for this organism.

The data concerning pyrimidines should be interpreted in view of the amount of growth observed in the controls lacking nitrogen. The growth noted in alloxan is to be attributed to decomposition products formed upon autoclaving, and not to alloxan itself (Wolf 1953). It would appear evident that the pyrimidines are, at best, very poor nitrogen sources for *P. chrysogenum*. Only cytosine and 5-methyl cytosine are possibly utilized; otherwise, the pyrimidine bases appear to be non-utilizable by this organism. The same would appear to be true of the methylated purines, caffeine, theobromine, and theophylline.

The purines in general, however, are excellent nitrogen sources for *P. chrysogenum*. Guanine and xanthine are the best, followed by adenine, uric acid, allantoin, and urea. Hypoxanthine is fairly well utilized, as is also 2, 6-diamino purine. The synthetic material isoguanine sulfate is rather poorly utilized.

Deoxyribonucleic acid and ribonucleic acid are utilized by *P. chrysogenum* with about equal effectiveness. Either is a good nitrogen source for this fungus. Upon comparison of the utilization of purines, purine nucleosides and purine nucleotides, little difference was found between hypoxanthine and inosine, or between xanthine and xanthosine. The situation is somewhat different, however, with adenine or guanine. Adenosine appears to be better utilized than adenylic acid, and adenine better than adenosine in equimolar concentrations. Similarly, guanine is a better nitrogen source than guanosine, which in turn is better than guanylic acid.

Among the pyrimidines, pyrimidine nucleosides and nucleotides, it is apparent that uracil, uridine and uridylic acid are poor nitrogen sources, though the latter two are utilized to a significant extent while uracil is not. Cytidine and cytidylic acid are much better nitrogen sources than cytosine

or any of the uracil derivatives.

DISCUSSION. The possibility of degradation of certain of the test compounds upon autoclaving, which would have an important bearing upon the results, has been discussed in an earlier paper (Wolf 1953). Only in the case of alloxan is there direct evidence that this occurred.

Purines in general appear to be good or excellent nitrogen sources for *P. chrysogenum*, as is true also of *Torula utilis* (Di Carlo, Schultz & McManus 1951), *Neurospora sitophila* (Wolf 1953) and *Fusarium oxysporum* var. *nicotianae* (Wolf 1955). Pyrimidines and methylated purines are either unutilized by *P. chrysogenum* or provide very poor sources of nitrogen for this organism, as is the case also with *Neurospora* and *Fusarium*. In *Torula*, however, certain pyrimidines proved to be favorable nitrogen sources.

The utilization by *P. chrysogenum* of adenine, guanine, hypoxanthine, xanthine, uric acid, allantoin and urea would indicate the presence of the enzymes adenase, guanase, xanthine oxidase, uricase, allatoinase and urease. These findings clearly suggest that the classical scheme of purine metabolism is operative in *P. chrysogenum*.

In *Neurospora crassa*, Pierce and Loring (1947) have concluded that the purine nucleosides play a more central role in nucleic acid metabolism than either the nucleotides or the free purine bases. Examination of the data presented in Table 1 concerning adenine, adenosine, adenylic acid, guanine, guanosine and guanylic acid reveals that in *P. chrysogenum* this is clearly not the case. The more efficient utilization of the free purine bases for growth may reflect a difference in the manner of synthesis of nucleic acids between the two organisms. With respect to the pyrimidines, pyrimidine nucleosides and pyrimidine nucleotides, however, cytidine and cytidylic acid are used with approximately equal effectiveness, and much better than is cytosine. The same is true of uridine and uridylic acid, which are significantly better for growth than is uracil, in equimolar concentration. It would appear, therefore, that the pyrimidine nucleosides and nucleotides play a more central role in growth, and perhaps in nucleic acid synthesis, in *P. chrysogenum* than do the free pyrimidine bases.

Finally, on the basis of the few fungi studied so far from this standpoint, it seems probable that each may have its own spectrum of activity and slight differences in the pattern of utilization of nucleic acid derivatives.

Literature Cited

Cochrane, V. W. 1958. Physiology of Fungi. New York. xiii plus 524 pp.

DiCarlo, F. J., Schultz, A. S. & McManus, D. K. 1951. The assimilation of nucleic acid derivatives and related compounds by yeasts. Jour. Biol. Chem. **189**: 151–157.

Moyer, A. J. & Coghill, R. D. 1946. Penicillin IX. The laboratory scale production of penicillin in submerged cultures by *Penicillium notatum* Westling (NRRL 832). Jour. Bact. **51**: 79–93.

Pierce, J. G. & Loring, H. S. 1947. Purine and pyrimidine antagonism in the pyrimidine deficient *Neurospora* mutant, no. 1298. Fed. Proc. **6**: 514–516.

Wolf, F. T. 1953. The utilization of nucleic acid derivatives by *Neurospora*. Mycologia **45**: 825–835.

————. 1955. Nutrition and metabolism of the tobacco wilt *Fusarium*. Bull. Torrey Bot. Club **82**: 343–354.

Table 1. *Growth of* ***Penicillium chrysogenum*** *in media containing various nucleic acid derivatives as sole sources of nitrogen.*

Nitrogen source	Mat weight, Mg.
CONTROLS	
No nitrogen	14 ± 4
Sodium nitrate	118 ± 16
Ammonium sulfate	97 ± 12
PYRIMIDINES	
Alloxan[1]	57 ± 12
Barbituric acid	15 ± 4
Cytosine	21 ± 4
5-methyl Cytosine	25 ± 4
Isocytosine	15 ± 3
Orotic acid	18 ± 4
2-Methyl, 5-Ethoxymethyl, 6-Amino Pyrimidine	17 ± 6
Thymine	14 ± 4
Uracil	13 ± 4
PURINES AND RELATED COMPOUNDS	
Adenine sulfate	132 ± 24
Guanine · HCl	183 ± 29
Hypoxanthine	90 ± 12
Isoguanine sulfate	30 ± 5
Xanthine	172 ± 38
Uric acid	120 ± 27
2,6-Diamino purine	67 ± 20
Allantoin	110 ± 18
Urea	94 ± 30
Guanidine · HCl	14 ± 7
METHYLATED PURINES	
Caffeine	19 ± 7
Theobromine	17 ± 5
Theophylline	12 ± 5
NUCLEOSIDES	
Adenosine	109 ± 35
Cytidine sulfate	78 ± 30
Guanosine	111 ± 22
Inosine	88 ± 30
Uridine	30 ± 7
Xanthosine	136 ± 10
NUCLEOTIDES	
Adenylic acid	99 ± 19
Cytidylic acid	81 ± 48
Guanylic acid	91 ± 53
Uridylic acid	30 ± 12
NUCLEIC ACIDS	
Deoxyribonucleic acid[2]	122 ± 13
Ribonucleic acid[3]	110 ± 40

[1] Decomposed on autoclaving.
[2] The quantity used was calculated on the basis of 16.7 per cent nitrogen content.
[3] The quantity used was calculated on the basis of 16.1 per cent nitrogen content.

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TORREYA

Harley Harris Bartlett

Edward G. Voss[1]

The life of Harley H. Bartlett, which came to its conclusion February 21, 1960, was one of those few in the annals of American botany which even a book-length biography would be hopelessly inadequate to cover. The extraordinary diversity of his interests, accomplishments, travels, and collections has already given to them a legendary quality.

HARLEY HARRIS BARTLETT
March 9, 1886–February 21, 1960

Harley Harris Bartlett was born March 9, 1886, at Anaconda, Montana, a son of Jonathan Hodgkin and Harriet (Potter) Bartlett. About 1899, the family moved to Indianapolis, Indiana, where Harley attended Shortridge High School. Here he came under the influence of several teachers, including Miss McClellan, Miss Marthens, and Miss Roda Selleck, to whose inspiration he frequently paid tribute in later years. (Miss Selleck, incidentally, was an aunt of Mrs. James B. Pollock, whose husband taught

[1] In addition to the more usual sources, I am indebted to an unpublished biographical sketch of Professor Bartlett by K. L. Jones, Rogers McVaugh, and W. R. Taylor, and to another by Thomas J. Cobbe, as well as to his sister, Miss Hazel Bartlett. Italicized numbers in parentheses refer to papers listed in the accompanying bibliography, which is based largely on a preliminary one compiled by Rogers McVaugh.

botany at the University of Michigan from 1898 to 1932). From his early youth in Montana, he displayed a studious interest in botany, geology, and chemistry, and he remained for two years after his graduation as an assistant, first in botany, then in chemistry, at Shortridge High School.

In 1904, he entered Harvard University, receiving an A.B. degree *cum laude* in chemistry in 1908. He took little or no formal work in botany except for Professor Fernald's course on the flora of New England and the Maritime Provinces. This was during his freshman year, and Fernald remained his "favorite professor" (*142*). For the next three years he was an undergraduate assistant to B. L. Robinson and M. L. Fernald at the Gray Herbarium. During the preparation of the 7th edition of *Gray's Manual*, which appeared in 1908, young Bartlett was given responsibility for the genus *Juncus*. During his undergraduate years, he published 10 papers (*1–10*), including one in German and one co-authored with Robinson. For only two subsequent years of his life (1948 and 1954) does his bibliography lack a title! (And he published eventually in nearly 40 different journals.)

He might have continued for graduate work in botany at Harvard, had not formal requirements become more rigid. The prospect of having to fulfil certain prerequisites before going on in botany irritated him. (He ever maintained an impatience with strict and specific educational requirements, and he seemed to enjoy the fact that he never earned nor accepted as an honor an advanced degree—although he took great pride in his students who had done so.) Therefore, declining an opportunity to continue at Harvard in chemistry, he entered a newly established field by accepting appointment as Chemical Biologist in the office of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

In Washington, his official work was largely in the field of plant nutrition, under the general supervision of Rodney H. True (*30, 46, 47, 50*), although his first paper published by the Bureau of Plant Industry was mostly on the taxonomy of *Dioscorea* (*22*). Here, too, he commenced his prolific publications on the genus *Oenothera* (*29, 32, 34, 35, 38, 39, 40, 41, 42, 43, 44, 48,* et seqq.—describing a total of more than 20 species and 25 varieties, forms, or mutations). Deeply inspired by the work of the Dutch botanist Hugo de Vries, Bartlett grew *Oenotheras* in the large Department of Agriculture plots near Dr. True's home in Glenn Dale, Maryland, making significant studies on their genetical behavior quite in addition to his important biochemical work for the U. S. D. A. When the great de Vries came to the United States, Bartlett accompanied him in the search for the origins of *O. lamarckiana* (*32*). An interest arose also in plant pigments and their genetical control (*33, 61, 63, 67, 69, 75*).

In 1915, the University of Michigan had a temporary vacancy on the botany faculty, and department chairman F. C. Newcombe induced Bartlett to come as acting assistant professor—with no guarantee of continuing beyond the academic year. His academic rise, however, was meteoric, commensurate with his abilities. By 1921 he was a full professor, and in 1922 he succeeded Newcombe as chairman of the department, a post which he held until 1947. In 1919, he was named Director of the Botanical Gardens, a job which he especially cherished and from which he could hardly help feeling he was being "booted out" by the simple requirement of a retirement furlough in 1955.

During his early days at Michigan, he continued his interests in plant biochemistry (*61, 67, 69, 70, 72, 75*) and the genetics of *Oenothera* (*52, 54, 59, 60, 64, 65, 66, 74, 82*). It is probably as an authority on the complexities of *Oenothera*, especially the balanced lethal concept, that he was most widely known, this fame being supplemented but hardly supplanted by his later additional diversions into anthropology, linguistics, and ethnobotany.

It was in 1918 that he made the first of many trips abroad, this time to Sumatra as a botanist with the United States Rubber Company. Here, with C. D. La Rue (also of the University of Michigan), he made such significant and valuable discoveries on selecting, growing, and grafting high-yielding strains of rubber (*71, 77, 78*) that his employers did not mind his taking a day off from time to time to collect plants and become acquainted with the inhabitants of the region.

On this occasion and a later visit in 1927 (*83, 86*), he cultivated an intense interest in the people and language of the Batak of Asahan on the east coast of Sumatra, on which he became a leading authority. An "adopted chief" of the tribe (*148*) and fluent in their language, he accumulated invaluable collections and data on both anthropological and botanical subjects (*68, 76, 81, 92, 93, 99, 101, 104, 145*). His interests in native uses of plant materials, in the native names of plants, and in the variations of both, particularly in Indonesia and the Philippines, led him into many fascinating studies in ethnobotany and linguistics (*68, 81, 90, 121, 148, 166, 168*). Altogether, his botanical and agricultural field work and research took him to Sumatra, Formosa (*85, 91*), Mexico, Guatemala and British Honduras (*95, 102, 105, 106, 107*), the Philippines (*112, 119*), Panama, Haiti, Argentina, Uruguay, and Chile, under the auspices of the University of Michigan, the U. S. Rubber Company, the Smithsonian Institution, the Carnegie Institution of Washington, the University of the Philippines, and the Office of Rubber Plant Investigations, Bureau of Plant Industry, U. S. D. A.

His exchange professorship at the University of the Philippines in 1934–35 established between that institution and the University of Michigan a friendly relationship which was to have far-reaching effects in rehabilitation of the former after World War II. In 1947, Professor Bartlett was called back as the guest of the Philippine government as visiting professor, educational consultant, and special adviser to the president of the University (*132*). In 1948, he was educational consultant for the Philippines in the United States, and chairman of the Commission on the Philippines, Pacific Science Board of the National Research Council.

After spending the summer of 1940 at the Gorgas Memorial Laboratory in the Canal Zone, investigating the relationship between plants and malarial mosquitoes, he was called to be principal botanist for the U. S. Office of Rubber Plant Investigations. During the next four years, he obtained in the Philippines high-yielding rubber plants, supervised their hazardous voyage to and planting in Haiti, studied in Mexico the cultivation of guayule, and encouraged its cultivation in South America. Although he was not really supposed to be making general plant collections in South America in those critical times, and could carry no equipment for the purpose, he managed to locate sufficient newspapers to make an amazingly large collection of specimens—all carefully pressed under the mattress of his bed.

His own Asiatic collections are extensive, and in addition he was responsible for the acquisition of thousands more specimens from Asia and Australia gathered by resident collectors or other explorers. The enormous residue of all this largely unworked material was only recently sorted, labeled if necessary (though not always identified), and is being formally accessioned by the University Herbarium. The total number of specimens will amount to 60,000 or more, with an even greater number of duplicates to distribute on exchange or for determination.

The official records of the Botany Department show that 32 University of Michigan students completed the Ph.D. under Bartlett's direction as committee chairman. The records cannot begin to tell of the hundreds more—not always in the field of botany—whom he helped both educationally and financially. He was a special friend of students from abroad. To the neighborhood children as well as his students, he was "Uncle Harley" —and a more kindly uncle one could scarcely imagine. An entrancing and popular lecturer, he had an undeniable discursive tendency, enthralling his classes just as he charmed his friends at social gatherings as an incomparable raconteur. "Local customs and local languages are among the things that make the world interesting," he once wrote in his diary, and his particular enjoyment in such things was evident.

His linguistic proficiency included not only the classics (who will write Latin descriptions at Michigan now?) but also the English language, which he hated to see abused. His sharp criticisms of plant sociological nomenclature (*97, 156*) must have made many an ecologist who did not know him personally, picture him as an especially ungentle villain! Frequently he discursed in a book review to protest unnecessary jargon and obscurity of language.

Additional subjects on which he wrote include paleobotany, (*51, 88, 89*); education

(*132, 178*); philately (*136, 147, 154, 159, 160, 161, 169*); the history of botany (*45, 117, 118, 120, 135, 149*); and miscellaneous history (*110, 127, 170*). There were, besides, numerous reviews and biographical or obituary notices (and it is in these categories that the bibliography is most likely to prove still incomplete). One might question the inclusion of reviews of books and articles in the accompanying bibliography, but a review by Bartlett was often as much a review of the subject as a review of the publication at hand, and his most characteristic writing is often to be found in his reviews. Of *Rhodora* under Fernald's editorship, he wrote that it "came to be one of the most highly personalized of scientific journals, in an era in which most editors have deemed it scandalous to reveal any personality at all" (*138, 142*); Bartlett himself was never reluctant to write a highly personalized article!

A passionate bibliophile, he combed the bookstores wherever he went, in search of old botanical volumes, local dictionaries and vernacular literature (*108*) and such items. He accumulated a vast library, specializing in pre-Linnaean botanical works, the history of botany, and other interests. His popular course in the history of botany was taught largely from two fascinating sources: his personal library of history-making works themselves, and his personal experiences. His botanical library is now being incorporated in the Herbarium Library of the University of Michigan. Although often critical of the lack of care given books by institutional libraries, Bartlett himself was generous in lending his own collection. I will always remember his handing me a handsomely bound 17th century folio, suggesting that it might be useful in a term paper I was writing for his course, and adding rather as an afterthought—without bothering to write his name in the work or to make any record of lending it—"Take good care of it; there's one other copy in the western hemisphere."

Blessed with an exceptionally retentive memory for really important things—like the exact location of an obscure work in the library, or the author of an article on a subject where his advice was sought, he had a convenient absentmindedness for such routine matters as the day's appointments or a promise to write a letter. Yes, there are still bundles of unopened mail several years old, and his correspondents who may have felt slighted at failure to receive a reply may rest assured they are in good company. In spite of a bibliography of quite respectable size, he left unpublished probably more research, ideas, and experiences than most of us will ever have. Never satisfied to finish one project before commencing another, he was, prior to his death, trying to continue as editor the recently revived Asa Gray Bulletin, to work on hybrid birches (of which he made hundreds of collections (*152*) during two field trips in the U. S. and Canada with graduate students in 1951 and 1952), to serve as president of the Institute for Regional Exploration, and to complete part III (and plan IV and V) of his exhaustive annotated bibliography on fire and primitive agriculture in the tropics (cf. *174, 171, 175;* it is expected that at least part III will be published posthumously).

At the time of his retirement (1956), the Regents of the University of Michigan conferred on him the titles Professor Emeritus of Botany and Director Emeritus of the Botanical Gardens. In his honor, his students and friends established (1955) in the Department of Botany the Harley Harris Bartlett Plant Exploration Fund—an appropriate recognition to the man who always had managed to find a way to finance a field trip in times when support from other sources was less easy than now to obtain.

Anyone with his strenuous experiences in field work around the world would find it hard to slow down in advancing years. Possibly if he had slowed down more, his heart would have held out longer, but he would not have been happy if he couldn't get to the library daily, give an occasional talk to a student group, or host a steak fry at a nearby lake for selected "oddments of people." He took the infirmities of age as lightly as he could. Told by a physician at University Hospital that he had diabetes and had better tell his wife he was going to stay in the hospital for a few days of metabolic tests, he burst into laughter. The physician wisely (and correctly) concluded that the reason for this outburst must be that he was unmarried. After several very critical days in an oxygen tent in July of 1959, he regained cognizance of his surroundings and one noon, still pale and weak, looked at me with his broad and inimitable cherubic grin and re-

marked, "They seem to think around here that I had a pretty close squeak." He "squeaked" by so well that he was up and around for several months before his heart finally failed.

Many were the honors which came to him. As early as the third edition (1921) of *American Men of Science*, his name was starred as one of the thousand Americans "whose work for science has been most valuable." In 1929 he was elected to membership in the American Philosophical Society. He served the Botanical Society of America as secretary in 1915–17, vice president in 1919, and president in 1927. He was president of the Michigan Academy of Science, Arts, and Letters for the year 1924–25. At the fiftieth anniversary meeting of the Botanical Society of America in 1956, he was one of the 50 outstanding botanists awarded a Certificate of Merit "for his unflagging support and encouragement of the whole field of botany and its students. . . ."

But the most enduring honor of all is in the lives and hearts of the hundreds of former students around the world—the "nephews" who have lost in their "Uncle Harley" a stimulating teacher, a warm and generous friend, and a genius in many fields whose standards will ever be a goal to maintain.

Bibliography

1. A new Juncus of the group Poiophylli. Rhodora **7**: 50–51. 1905.
2. Polygonum exsertum in Massachusetts. Ibid. **7**: 140. 1905.
3. The salt-marsh Iva of New England. Ibid. **8**: 25–26. 1906.
4. Juncus compressus in the province of Quebec. Ibid. **8**: 233. 1906.
5. New plants from Guatemala and Mexico, collected chiefly by C. C. Deam. Proc. Am. Acad. Arts & Sci. **43**: 48–60. 1907. (With B. L. Robinson.)
6. The retrograde color varieties of Gratiola aurea. Rhodora **9**: 122–124. 1907.
7. Flower color of the American Diervillas. Ibid. **9**: 147–148. 1907.
8. Ueber das vorkommen von Juncus Dudleyi Wiegand in Deutschland. Allgemeine botanische Zeitschrift **13**: 147–148. 1907.
9. Some new Washington plants. Bot. Gaz. **44**: 302–304. 1907.
10. The type locality of Sphagnum Faxonii. Rhodora **10**: 113–114. 1908.
11. A synopsis of the American species of Litsea. Proc. Am. Acad. Arts & Sci. **44**: 597–602. 1909.
12. Notes on Mexican and Central American alders. Ibid. **44**: 609–612. 1909.
13. The purple-flowered Androcerae of Mexico and the southern United States. Ibid. **44**: 627–629. 1909.
14. Descriptions of Mexican phanerogams. Ibid. **44**: 630–637. 1909.
15. Nolina in the south Atlantic states. Rhodora **11**: 80–82. 1909.
16. Note on Oxalis stricta var. viridiflora. Ibid. **11**: 118–119. 1909.
17. The geographic ranges of certain Junci Poiophyli. Ibid. **11**: 155–157. 1909.
18. Rupture of the exoperidium in Calostoma Ravenelii. Ibid. **11**: 197–198. 1909.
19. The submarine Chamaecyparis bog at Woods Hole, Massachusetts. Ibid. **11**: 221–235. 1909.
20. Vernonia georgiana, a new species related to V. oligophylla. Ibid. **12**: 171–172. 1910.
21. The North American species of Panicum. [Review.] Ibid. **12**: 218–220. 1910.
22. The source of the drug Dioscorea, with a consideration of the Dioscoreae found in the United States. U. S. Dept. Agr., Bur. Plant Industry, Bull. 189. pp. 29. 1910.
23. Botanical evidence of coastal subsidence. Science, N. S., **33**: 29–31. 1911.
24. Populus virginiana and P. angulata. Rhodora **13**: 12–14. 1911.
25. Ptelea mollis var. cryptoneura, a wafer-ash of the Georgia sand-hills. Ibid. **13**: 80–82. 1911.
26. A supplemental description of Euphorbia ephedromorpha. Bull. Torrey Bot. Club **38**: 343–346. 1911.
27. Euphorbia arundelana, an ally of Euphorbia Ipecacuanhae. Rhodora **13**: 163–165. 1911.
28. On gynodioecism in Plantago lanceolata. Ibid. **13**: 199–206. 1911.

29. Systematic studies on Oenothera,—I. Oenothera Tracyi, sp. nov. Ibid. **13**: 209–211. 1911.
30. Absorption and excretion of salts by roots, as influenced by concentration and composition of culture solutions. I.—Concentration relations of dilute solutions of calcium and magnesium nitrates to pea roots. U. S. Dept. Agr., Bur. Plant Industry, Bull. 231. pp. 36. 1912. (With R. H. True.)
31. A flora of the New Jersey pine barrens. [Review.] Rhodora **14**: 94–96. 1912.
32. The evening-primroses of Dixie Landing, Alabama. Science, N. S. **36**: 599–601. 1912. (With H. deVries.)
33. The purpling chromogen of a Hawaiian Dioscorea. U. S. Dept. Agr., Bur. Plant Industry, Bull 264. pp. 19. 1913
34. Systematic studies on Oenothera,—II. The delimitation of Oenothera biennis L. Rhodora **15**: 48–53. 1913.
35. Systematic studies on Oenothera,—III. New species from Ithaca, New York. Ibid. **15**: 81–85. 1913.
36. Inheritance of sex forms in Plantago lanceolata. Ibid. **15**: 173–178. 1913.
37. A second edition of Britton and Brown's Illustrated Flora. [Review.] Ibid. **15**: 220–224. 1913.
38. Systematic studies on Oenothera,—IV. Oe. franciscana and Oe. venusta, spp. novv. Ibid. **16**: 33–37. 1914.
39. An account of the cruciate-flowered Oenotheras of the subgenus Onagra. Am. Jour. Bot. **1**: 226–243. 1914.
40. Twelve elementary species of Onagra. Cybele Columbiana **1**: 37–56. 1914.
41. Additional evidence of mutation in Oenothera. Bot. Gaz. **59**: 81–123. 1915.
42. Systematic studies on Oenothera,—V. Oe. Robinsonii and Oe. cleistantha spp. novv. Rhodora **17**: 41–44. 1915.
43. The mutations of Oenothera stenomeres. Am. Jour. Bot. 2: 100–109. 1915.
44. Mutation *en masse*. Am. Nat. **49**: 129–139. 1915.
45. The experimental study of genetic relationships. Am. Jour. Bot. 2: 132–155. 1915.
46. The exchange of ions between the roots of Lupinus albus and culture solutions containing one nutrient salt. Ibid. 2: 255–278. 1915. (With R. H. True.)
47. The exchange of ions between the roots of Lupinus albus and culture solutions containing two nutrient salts. Ibid. 2: 311–323. 1915. (With R. H. True.)
48. Mass mutation in Oenothera pratincola. Bot. Gaz. **60**: 425–456. 1915.
49. Parthenium Lloydii, a new Mexican guayule. Torreya **16**: 45–46. 1916.
50. The exchange of ions between the roots of *Lupinus albus* and culture solutions containing three nutrient salts. Am. Jour. Bot. 3: 47–57. 1916. (With R. H. True.)
51. Coniferous woods of the Potomac formation. Am. Jour. Sci. **41**: 276–293. 1916. (With E. W. Sinnott.)
52. A comparison of the wood structure of *Oenothera stenomeres* and its tetraploid mutation *gigas*. Genetics **1**: 177–184. 1916. (With W. W. Tupper.)
53. The botanical work of Edward Lee Greene. Torreya **16**: 151–175. 1916.
54. The status of the mutation theory, with especial reference to Oenothera. Am. Nat. **50**: 513–529. 1916.
55. Anomalous endosperm and the problem of bud sports. [Review.] Bot. Gaz. **62**: 247–248. 1916.
56. Linkage and crossing-over in oats. [Review.] Ibid. **62**: 323–325. 1916.
57. Patrogenesis. [Review.] Ibid. **62**: 331–332. 1916.
58. Mutation in Matthiola annua, a "Mendelizing" species. [Review.] Ibid. **63**: 82–83. 1917.
59. Matroclinic inheritance in mutation crosses of Oenothera Reynoldsii. Am. Jour. Bot. **4**: 119–144. 1917. (With C. D. LaRue.)
60. The relation of mutational characters to cell size. Genetics 3: 93–106. 1918. (With W. W. Tupper.)
61. The flavones of Rhus. Am. Jour. Bot. 5: 112–119. 1918. (With C. E. Sando.)
62. Cell measurement as an aid in the analysis of quantitative variation. Ibid. 5: 192–206. 1918. (With W. Brotherton, Jr.)

63. Purple bud sport on pale flowered lilac (Syringa persica). Bot. Gaz. **65**: 560–562. 1918. (With F. Cobb.)
64. An analysis of the changes involved in a case of progressive mutation. Genetics **3**: 207–224. 1918. (With C. D. LaRue.)
65. A case of Mendelian segregation in Oenothera pratincola. Rep. Mich. Acad. **20**: 152. 1919. (With F. Cobb.)
66. On Mendelian inheritance in crosses between mass-mutating and non-mass-mutating strains of *Oenothera pratincola*. Jour. Wash. Acad. Sci. **9**: 462–483. 1919. (With F. Cobb.)
67. Rutin, the flavone pigment of Escholtzia californica Cham. Jour. Biol. Chem. **41**: 495–501. 1920. (With C. E. Sando.)
68. The manufacture of sugar from *Arenga saccharifera* in Asahan, on the east coast of Sumatra. Rep. Mich. Acad. **21**: 155–165. 1920.
69. Occurrence of quercetin in Emerson's brown-husked type of maize. Jour. Agr. Res. **22**: 1–4. 1921. (With C. E. Sando.)
70. Notes on the organic acids of Pyrus coronaria, Rhus glabra, and Acer saccharum. Ibid. **22**: 221–229. 1921. (With C. E. Sando.)
71. A demonstration of numerous distinct strains within the nominal species *Pestalozzia Guepini* Desm. Am. Jour. Bot. **9**: 79–92. 1922. (With C. D. LaRue.)
72. The carbohydrate content of the seed of Asparagus officinalis L. Jour. Biol. Chem. **51**: 93–102. 1922. (With W. E. Cake.)
73. Color types of Corallorrhiza maculata Raf. Rhodora **24**: 145–148. 1922.
74. A preliminary notice of genetical studies of resistance to mildew in Oenothera. Am. Jour. Bot. **9**: 446–458. 1922. (With P. J. Klaphaak.)
75. Pigments of the Mendelian color types in maize: Isoquercitrin from brown-husked maize. Jour. Biol. Chem. **54**: 629–645. 1922. (With C. E. Sando.)
76. The grave-post (anisan) of the Batak of Asahan. Pap. Mich. Acad. **1**: 1–58. 1923.
77. A leaf-fall disease of *Hevea brasiliensis* Muell.-Arg. due to *Glocosporium alborubrum* Petch. Ibid. **2**: 73–90. 1923. (With C. D. LaRue.)
78. Diplodia disease of *Hevea brasiliensis*. Ibid. **2**: 91–107. 1923. (With C. D. LaRue.)
79. A flora of the White Mountain region. [Review.] Bot. Gaz. **78**: 466–467. 1924.
80. The varieties of Corallorrhiza maculata. Rhodora **27**: 11–14. 1925.
81. Sumatran plants collected in Asahan and Karoland, with notes on their vernacular names. Pap. Mich. Acad. **6**: 1–66. 1926.
82. The inheritance of red bud color in crosses of *Oenothera pratincola* and related forms. Ibid. **6**: 77–132. 1926. (With F. C. Blanchard.)
83. A corky-barked mutation of Hevea brasiliensis. Bot. Gaz. **84**: 200–207. 1927.
84. Frederick Charles Newcombe, 1858–1927. Am. Jour. Bot. **15**: 1–5. 1928. (With J. B. Pollock.)
85. A botanical trip to Formosa. Explorations and Field-Work of the Smithsonian Institution in 1927. pp. 85–92. 1928.
86. The fast-disappearing flora of Sumatra. Ibid. pp. 93–100. 1928.
87. Obituary of F. C. Newcombe—1858–1927. Rep. Mich. Acad. **30–31**: 78–80. 1929.
88. Fossils of the carboniferous coal pebbles of the glacial drift at Ann Arbor. Pap. Mich. Acad. **9**: 11–28. 1929.
89. The genus Triletes, Reinsch. Ibid. **9**: 29–38. 1929.
90. Color nomenclature in Batak and Malay. Ibid. **10**: 1–52. 1929.
91. The carvings of the Paiwan of Formosa. Ibid. **10**: 53–58. 1929.
92. The labors of the *datoe:* Part I. An annotated list of religious, magical and medical practices of the Batak of Asahan. Ibid. **12**: 1–74. 1930.
93. The labors of the *datoe:* Part II. Directions for the ceremonies. Ibid. **14**: 1–34. 1931.
94. Calvin Henry Kauffman. Univ. Mich. Council and Senate Records, 1929–1932, pp. 74–76. 1932. (With T. R. Running & E. B. Mains.)
95. A biological survey of the Maya area. Bull. Torrey Bot. Club **59**: 7–20. 1932.
96. Fruits and other plants. p. 88 in: Karanis: The temples, coin hoards, botanical

and zoological reports, seasons 1924–31, ed. by A. E. R. Boak. Ann Arbor: Univ. Mich. Press. 1933.

97. The nomenclature of plant associations. Ecology **14**: 157–162. 1933.
98. Opportunity for investigation in natural history by high-school teachers. XXI. Suggestions to the local botanist. Jour. Mich. Schoolmasters' Club **68**: 109–116. XXVI. Conclusion. Ibid. 143–145. 1933. [Note: the entire symposium reprinted by Univ. Mich. Press and repaged, with a short prefatory note by H. H. Bartlett, Chairman, on p. 4 and the two chapters by him becoming pp. 91–98 and 125–127, respectively.]
99. The sacred edifices of the Batak of Sumatra. Univ. Mich., Occ. Contr. Mus. Anthropol., No. 4. pp. 31. 1934.
100. In memoriam: James Barkley Pollock. Mich. Alumnus **41**: 27–28. 1934.
101. The problem of Negrito and "Vedda" elements in the population of Sumatra. Proc. 5th Pac. Sci. Cong., **4**: 2851–2862. 1934.
102. Certain Desmonci (Palmae) of Central America and Mexico. Jour. Wash. Acad. Sci. **25**: 81–88. 1935.
103. The Michigan botanical expedition for 1934. Mich. Alumnus Quart. Rev. **41**: 357–358. 1935.
104. The Batak lands of north Sumatra, from the standpoint of recent American botanical collections. Univ. Philip. Nat. & Appl. Sci. Bull. **4**: 211–323. 1935.
105. Botany of the Maya Area: Miscellaneous Papers I. A method of procedure for field work in tropical American phytogeography based upon a botanical reconnaissance in parts of British Honduras and the Petén Forest of Guatemala. Carnegie Inst. Publ. **461**: 1–26. 1935.
106. Ibid. II. Various Palmae Corypheae of Central America and Mexico. Ibid. **461**: 27–41. 1935.
107. Ibid. III. Scheelea lundellii, a new "corozo" palm from the Department of Petén, Guatemala. Ibid. **461**: 43–47. 1935.
108. Vernacular literature in the Philippines. Mich. Alumnus Quart. Rev. **42**: 214–227. 1936.
109. James Barkley Pollock. Univ. Mich. Council and Senate Records, 1934–1936, pp. 52–56. 1936. (With B. M. Davis & J. F. Shepard.)
110. Nationalism, imperialism, and spheres of influence in natural science. Nat. Res. Counc. Philip. Is. Bull. **12**: 75–97. 1937.
111. The Papers of the Michigan Academy—Vol. XXII. [Review.] Mich. Alumnus Quart. Rev. **44**: 92–93. 1937.
112. Jar burials in the Babuyan group, Philippine Islands, especially those of Dalupiri Island. Pap. Mich. Acad. **23**: 1–20. 1938.
113. Marine algae. [Review.] Mich. Alumnus Quart. Rev. **44**: 274–275. 1938.
114. The Michigan Academy Papers, Vol. XXIII. [Review.] Ibid. **44**: 372–373. 1938.
115. The annual Michigan Academy Papers. [Review.] Ibid. **46**: 91–92. 1939.
116. Sumatran Palms. I. Calamoxleya, a subgenus of Calamus typified by *C. leiospathus*, a new species related to *C. Oxleyanus*. Pap. Mich. Acad. **25**: 3–12. 1940.
117. History of the generic concept in botany. Bull. Torrey Bot. Club **67**: 349–362. 1940.
118. The reports of the Wilkes Expedition, and the work of the specialists in science. Proc. Am. Philos. Soc. **82**: 601–705. 1940.
119. Cinchona cultivation and the production of totaquina in the Philippines. Univ. Philip. Nat. & Appl. Sci. Bull. **8**: 111–142. 1941. (With Joaquin Marañon.)
120. Asa Gray's nonresident professorship: The beginning of the University in Ann Arbor. Mich. Alumnus Quart. Rev. **47**: 215–226. 1941.
121. The geographic distribution, migration, and dialectical mutation of certain plant names in the Philippines and Netherlands India, with special reference to the materia medica of a Mangyan mediquillo. Proc. 6th Pac. Sci. Cong., **4**: 85–109. 1941.
122. Frank Nelson Blanchard. Univ. Mich. Council and Senate Records, 1936–1941, pp. 138–145. 1941. (With A. G. Ruthven and G. LaRue.)

123. The end of an era in the Philippines. [Review.] Mich. Alumnus Quart. Rev. **48**: 177–179. 1942.
124. *Oenothera Burkartiana*, una nueva especie argentina del subgénero *Raimannia* de un grupo que aparenta ser *Onagra*. Darwiniana **6**: 203–210. 1943.
125. The Botanical Garden at the University of Michigan. Mich. Alumnus Quart. Rev. **49**: 162–173. 1943.
126. The Botanical Gardens. pp. 506–512 in: The University of Michigan—an Encyclopedic Survey, III. Ann Arbor: Univ. Mich. Press. 1943.
127. An English bill in chancery, 1644, concerning Roger Williams and his brothers. Jour. New England Hist. Geneal. Soc. **97**: 176–181. 1943.
128. Progress of the Michigan Academy. [Review.] Mich. Alumnus Quart. Rev. **51**: 89–91. 1944.
129. Gathering scientific materials—How alumni can help. Univ. Mich. Official Publ. **46**: No. 107: 10–15. 1945.
130. A program of botanical collecting and study for servicemen. Chron. Bot. **9**: 135–137. 1945. (With E. H. Walker.)
131. Michigan Academy Papers. [Review.] Mich. Alumnus Quart. Rev. **52**: 374–376. 1946.
132. The status of the University of the Philippines and of higher education in the Philippines. Address at the convocation of the University of the Philippines in celebration of the first anniversary of the Republic. pp. 21. Manila: Univ. Philip. 1947.
133. Lycopodium Copelandianum, a Sumatran clubmoss. Bull. Torrey Bot. Club **74**: 369–373. 1947. (With R. C. Y. Chou.)
134. Report of the committee of the Botanical Society of America on the United States National Herbarium. Am. Jour. Bot. **34**: 296–297. 1947. (With others.)
135. Fifty-five rare books from the botanical library of Mrs. Roy Arthur Hunt. Clements Library. Bull. **57**. pp. 55. 1949. Ann Arbor: Clements Library [of the Univ. of Mich.]
136. Guides to geographic names in China. [Review.] China Clipper **13**: 60. 1949.
137. Goethe as a biologist. Mich. Alumnus Quart. Rev. **55**: 300–312. 1949.
138. Gray's Manual of Botany . . . 8th ed. [Review.] Science **112**: 658–660. 1950.
139. The annual volume of Michigan Academy Papers. [Review.] Mich. Alumnus Quart. Rev. **57**: 264–265. 1951.
140. Botanical Souvenir of "Operation Crossroads". Ibid. **57**: 266–267. 1951.
141. The Flora of Bic and the Gaspé Peninsula, Quebec. [Review.] Science **113**: 130–131. 1951.
142. Fernald as a reviser of Gray's Manual. Rhodora **53**: 44–55. 1951.
143. Regression of × Quercus Deamii toward Quercus macrocarpa and Quercus Muhlenbergii. Ibid. **53**: 249–264. 1951.
144. Local floras described, analyzed. [Reviews.] Sci. Month. **72**: 266–268. 1951.
145. A tiger charm with inscribed invocation, from the Pardembanan Batak of Silo Maradja, Asahan, Sumatra. Ethnos **16**: 71–82. 1951.
146. Radiocarbon datability of peat, marl, caliche, and archeological materials. Science **114**: 55–56. 1951.
147. The Communist Silver-Yuan stamps of China. China Clipper **15**: 92–97. 1951.
148. A Batak and Malay chant on rice cultivation, with introductory notes on bilingualism and acculturation in Indonesia. Proc. Am. Philos. Soc. **96**: 629–652. 1952.
149. History of the Gray Memorial Botanical Association and the Asa Gray Bulletin [with accompanying correspondence]. Asa Gray Bull., n.s., **1**: 3–30. 1952.
150. Mrs. Roy Arthur Hunt's Pittsburgh exhibition of botanical books, prints and drawings. Ibid. **1**: 30–31. 1952.
151. Walter Tennyson Swingle: Botanist and exponent of Chinese civilization [with accompanying correspondence]. Ibid. **1**: 107–132. 1952.
152. Collecting Betula in the Great Lakes Region. Ibid. **1**: 145–162. 1952. (With C. D. Richards.)

153. A flora of Manitoba in prospect. Ibid. **1**: 162. 1952.
154. Proposal for a postage stamp commemorating Asa Gray. Ibid. **1**: 325–329. 1952.
155. About cultivated plants and weeds, man's camp followers. [Review.] Ibid. **1**: 330–334. 1952.
156. The Braun-Blanquet system of nomenclature for plant sociology examined from the standpoint of linguistic propriety. Ibid. **1**: 335–343. 1952.
157. A letter from Dr. C. L. Shear, to whom we dedicate this volume. Ibid. **1**: 344–348. 1952.
158. Maps of individual Michigan lakes: An aid to precision in botanical work. [Review.] Ibid. **1**: 351–352. 1952.
159. New varieties from Korea. China Clipper **16**: 14–17. 1952.
160. A second type of the souvenir sheet honoring New Zealand . . . in the Korean flag issue of 1951. Ibid. **16**: 66–68. 1952.
161. Third major type of the U. S. flag stamp in the Korean issue of 1951. Ibid. **16**: 85–88. 1952.
162. Regional botany. [Review.] Sci. Month. **75**: 123–124. 1952.
163. Botanical reviews of books on the Antarctic, the Himalayas, and Tibet. Asa Gray Bull., n. s., **2**: 51–68. 1953.
164. The world's herbaria: A review of "Index Herbariorum." Ibid. **2**: 69–75. 1953.
165. Current status of the Gray Memorial Botanical Association. Ibid. **2**: 74–76. 1953.
166. English names of some East-Indian plants and plant products. Ibid. **2**: 149–176. 1953.
167. "Farwelliana": A review, with notes on the herbarium and botanical library of Parke, Davis and Company and on Ma-Huang. Ibid. **2**: 315–321. 1953.
168. Malayan words in English. Mich. Alumnus Quart. Rev. **60**: 40–55. 1953.
169. The Korean 200-won and 300-won surcharged stamps of 1951. China Clipper **17**: 86–88. 1953.
170. American captivities in Barbary. Mich. Alumnus Quart. Rev. **61**: 238–254. 1955.
171. Fire in relation to primitive agriculture and grazing in the tropics: Annotated bibliography. Ann Arbor: Univ. Mich. Botanical Gardens. pp. 568. 1955. [Processed]
172. Foreword [to History and philosophy of Japanese flower arrangement, by M. C. Wood]. Asa Gray Bull., n.s., **3**: 3–5. 1955.
173. William Herbert Hobbs (1864–1953). Am. Philos. Soc. Yearb. 1955: 442–460. 1956.
174. Fire, primitive agriculture, and grazing in the tropics. pp. 692–720 in: Man's role in changing the face of the earth, ed. by W. L. Thomas, Jr. Chicago: Univ. of Chicago Press. 1956.
175. Fire in relation to primitive agriculture and grazing in the tropics: Annotated bibliography. Vol. II (A-G, Tropics in general; H-J, South Asia and Oceania). Ann Arbor: Univ. Mich. Dept. of Botany. pp. 873. 1957. [Processed]
176. Foreword [to Persian diary, by W. N. Koelz]. Asa Gray Bull., n.s., **3**: 133–135. 1957.
177. Otto Degener: Botanist of the south seas. Ibid. **3**: 197–198. 1957.
178. Science and education. Mich. Alumnus Quart. Rev. **64**: 277–288. 1958.
179. Henry Arthur Sanders (1868–1956). Am. Philos. Soc. Yearb. 1958: 143–155. 1959.

Additions and Corrections to a Flora of Rockland County, New York.

J. HARRY LEHR.

Further studies both in the herbarium and in the field have given the writer the opportunity to make the following additions and corrections to his "Annotated Preliminary Catalogue of the Vascular Flora of Rockland County, New York." (See Bull. Torrey Club, **83**: 435–438, 1956; **84**: 48–56, 126–134, 206–213, 310–317, 388–392, 450–452, 1957; **85**: 488–489, 1958; and **87**: 59–61, 1960.) The abbreviations, the references, and the phylogeny of this supplement remain unchanged from the original catalogue.

POLYPODIACEAE

DRYOPTERIS SPINULOSA (O. F. Muell.) Watt var. INTERMEDIA (Muhl.) Underw. Intermediate Shield Fern. Ramapo. (H)

TYPHACEAE

TYPHA GLAUCA Godr. Glaucous Narrow-leaved Cat Tail. Stony Point. (H)

HYDROCHARITACEAE

ELODEA NUTTALLII (Planch.) St. John. Narrow-leaved Waterweed. Stony Point. (H)

GRAMINEAE

* BROMUS PURGANS L. Canadian Brome. Clarkestown. (H)

* GLYCERIA MELICARIA (Michx.) F. T. Hubbard. Slender Manna Grass. Ramapo. (H)

* G. STRIATA (Lam.) Hitch. Fowl Manna Grass. Ramapo (H)

ERAGROSTIS PECTINACEA (Michx.) Nees. Small Tufted Lovegrass. Ramapo. (H)

DESCHAMPSIA FLEXUOSA (L.) Trin. Crinkled Hairgrass. Stony Point. Our deposited material bears spikelets which are greenish, rather than pale, bronze or purplish. (H)

DANTHONIA SPICATA (L.) Beauv. ex Roem. and Schult. Poverty Oat-Grass. Ramapo. (H)

* AGROSTIS ALBA L. Redtop. Clarkestown. (H)

* PANICUM MILIACEUM L. Broom-Corn Millet. A single plant growing on a roadside. Ramapo. (H)

* P. MICROCARPON Muhl. Tiny-fruited Panic Grass. Stony Point. (H)

CYPERACEAE

* CAREX SEORSA Howe. Howe's Sedge. Haverstraw. (H)

ERIOCAULACEAE

ERIOCAULON SEPTANGULARE With. Seven-angled Pipewort. Our vouchers were found at an altitude of 828 feet as opposed to the altitudinal range of sea-level-750 feet published in Taylor's "Flora of the Vicinity of New York." Haverstraw. (H)

JUNCACEAE

* JUNCUS TENUIS Willd. var. ANTHELATUS Wieg. Ramapo. (H)

MYRICACEAE

* MYRICA GALE L. var. SUBGLABRA (Chev.) Fern. Sweet Gale. A single station for a rarity in southern New York State, i.e. the southernmost station with the exception of Long Island. Haverstraw. (H)

FAGACEAE

QUERCUS RUBRA L. var. BOREALIS (Michx. f.) Farw. Northern Red Oak. Altitude 800 feet. Haverstraw. (H)

* X Q. LOWELLII Sargent. This is the much disputed hybrid between *Q. rubra* var. *borealis* and *Q. ilicifolia*. Our deposited material was collected in dry, rocky, upland woods at an altitude of 800 feet from a small tree about 18 feet tall with both parents common in the area. The trunk of the hybrid is a smooth gray and it bears leaves typical of *Q. ilicifolia* although the larger ones have terminal lobes similar to *Q. rubra* var. *borealis*. The texture of the leaves throughout are strongly subcoriaceous typical of *Q. ilicifolia* but are paler green and finely pubescent beneath instead of having a close gray tomentosity. The cup of the acorn is hemispherical, abruptly enlarged above the base enclosing about two thirds of the nut. Its scales are appressed but not as coarse as *Q. ilicifolia* nor as fine as *Q. rubra* var. *borealis*. Haverstraw. (H)

POLYGONACEAE

POLYGONUM CESPITOSUM Blume var. LONGISETUM (De Bruyn) Stewart. Long-bristled Smartweed. Ramapo. (H)

CRUCIFERAE

RAPHANUS RAPHANISTRUM L. forma SULPHUREUS (Babey) Hayek. Wild radish. This is a form with yellow petals and with yellow veins. Clarkestown. (H)

RORIPPA ISLANDICA (Oeder) Borbas var. FERNALDIANA Butt. & Abbe. The variety should be substituted for the typical species in our original list. Marsh Cress. Clarkestown. (H)

SAXIFRAGACEAE

* DEUTZIA SCABRA Thunb. Deutzia. A single plant remaining after cultivation. Clarkestown. (H)

LEGUMINOSAE

* LATHYRUS LATIFOLIUS L. Everlasting Pea. Ramapo. (H)

LINACEAE

LINUM VIRGINIANUM L. Wild Yellow Flax. Clarkestown. (H)

OXALIDACEAE

OXALIS EUROPAEA Jord. forma CYMOSA (Small) Wieg. European Wood-Sorrel. Ramapo. (H)

MALVACEAE

* MALVA VERTICILLATA L. Whorled Mallow. Ramapo. (H)

GUTTIFERAE

* HYPERICUM MAJUS (Gray) Britt. Larger Canadian St. John's-Wort. Ramapo. (H)

CISTACEAE

LECHEA VILLOSA Ell. Pinweed. Ramapo. (H)

VIOLACEAE

VIOLA FIMBRIATULA Sm. forma GLABRATA Pennell. In this form the leaf blades are glabrous. It could be confused with *V. sagittata* but our deposited material has the oblong-ovate leaves, the ciliate auricles and brown seeds of typical *V. fimbriatula*. Ramapo. (H)

* V. TRILOBA Schwein. var. DILATATA (Ell.) Brainerd. The author of this paper originally listed this material as *V. palmata* but the veining in the deposited material is pedate rather than palmate. Fernald in Gray's manual gives its range as "north to Pa." whereas Gleason in the New Britton & Brown says "north to Va." Our station is located at virtually the southernmost point in the county. Orangeburg. (H)

ONAGRACEAE

LUDWIGIA ALTERNIFOLIA L. Seedbox. Gleason's New Britton & Brown says "Petals 3–4 mm. long, about equaling the sepals," whereas Munz's monograph of the genus (Torrey Bull. 71, 151–165, 1944) says "sepals 7–10 mm. long; petals 8–10 mm. long;". Our deposited material bears sepals 9 mm. long and petals 8 mm. long. Clarkestown. (H)

* OENOTHERA TETRAGONA Roth. Common Sundrops. Clarkestown. (H)

ARALIACEAE

* ARALIA SPINOSA L. Devil's Walking Stick. A single specimen, doubtless an escape. Ramapo. (H)

UMBELLIFEREAE

SANICULA CANADENSIS L. Canada Snakeroot. Clarkestown. (H)

* OSMORHIZA LONGISTYLIS (Torr.) D. C., var. BRACHYCOMA Blake. Anise-Root. Ramapo. (H)

* SIUM SUAVE Walt. forma CARSONII (Durand) Fassett. Water Parsnip. Orangetown. (H)

* CONIOSELINUM CHINENSE (L.) BSP. Hemlock Parsley. A single station on a roadside in a populated area. Ramapo. (H)

OLEACEAE

* LIGUSTRUM OBTUSIFOLIUM Sieb. & Zucc. Obtuse-leaved Privet. In the deposited material the leaves are completely glabrous lacking pubescence on the midrib beneath. There is also great variation in leaf-form from obtuse to acute, and one specimen observed also bore apiculate leaves. Remaining after cultivation. Orangeburg, Clarkestown. (H)

ASCLEPIADACEAE

ASCLEPIAS EXALTATA L. Poke Milkweed. Ramapo. (H)

LABIATAE

* THYMUS SERPYLLUM L. Creeping Thyme. Ramapo. (H)

SCROPHULARIACEAE

GRATIOLA NEGLECTA Torr. Clammy Hedge Hyssop. Ramapo. (H)

* VERONICA LONGIFOLIA L. forma GLABRA (Schrad.) Aschers. & Graebn. Long-leaved Speedwell. Ramapo. (H)

PHRYMACEAE

PHRYMA LEPTOSTACHYA L. Lopseed. Stony Point, Clarkestown. (H)

COMPOSITAE

* SOLIDAGO PUBERULA Nutt. Downy Goldenrod. Haverstraw. (H)

S. GRAMINIFOLIA (L.) Salis. var. NUTTALLII (Greene) Fern. Narrow-leaved Goldenrod. The author originally listed the species only but continued study and observation convinces him that all of his material should be considered varietal. It is significant that W. C. Muenscher in his "Weeds of New York State" and Robert L. Schaeffer Jr. in his "Flora of Northampton County, Pennsylvania" list the variety only. In all of this county's collections the upper part of the stem, the branches, branchlets, and leaves are hirtellous. General. (H)

ASTER DIVARICATUS L. White Wood Aster. Clarkestown. (H)

A. MACROPHYLLUS L. var. IANTHINUS (Burgess) Fern. Large-leaved Aster. Haverstraw. (H)

ERIGERON PHILADELPHICUS L. Philadelphia Fleabane. Ramapo. (H)

* RUDBECKIA LACINIATA L. var. HORTENSIS Bailey. Golden-Glow. An occasional escape. Ramapo, Haverstraw. (H)

GALINSOGA CILIATA (Raf.) Blake. Quickweed. General. (H)

* ARTEMISIA ANNUA L. Annual Wormweed. Stony Point. (H)

ERECHTITES HIERACIFOLIA (L.) Raf. var. INTERMEDIA Fern. A debatable variety with "upper leaves rapidly reduced to bracts below the inflorescence." Ramapo. (H)

CIRSIUM MUTICUM Michx. Swamp Thistle. Ramapo. (H)

* CENTAUREA VOCHINENSIS Bernh. Tyrol Knapweed. Stony Point. (H)

* HYPOCHOERIS RADICATA L. Gosmore. Clarkestown. (H)

* TRAGOPOGON PRATENSIS L. Yellow Goatsbeard. Ramapo. (H)

LACTUCA SCARIOLA L. forma INTEGRIFOLIA (Bogenh.) G. Beck. Our deposited voucher and all of our undeposited material bear unlobed leaves in the upper half and lobed

rather than pinnatifid leaves in the lower half, therefore the form should be substituted for the species in our original list.

* CREPIS CAPILLARIS (L.) Wallr. Hawk's-Beard. Ramapo. (H)

* HIERACIUM FLORIBUNDUM Wimm. & Grab. Smooth-leaved Hawkweed. Ramapo.

SPRING VALLEY, NEW YORK.

FIELD TRIP REPORTS

Aug. 6. Franklin Lakes Area, N. J. On the interesting terrain, under midsummer sky the following plants were colorful and attractive: Blue vervain, white vervain, cardinal flower, large skullcap, small skullcap, whorled milkwort, field milkwort, spotted wintergreen, and *Helianthus mollis*. A field of tall blazing star intermingled with early goldenrod was a delight for those taking color pictures. An area of heath was studied, the plant believed to be an escape. Attendance: 15. Leaders, Harry and Lucy Kemp.

Sept. 18. Mianus River Gorge, N. Y. In spite of rainy weather a group of 15 attended, among whom were two young graduate student assistants from the N. Y. Botanical Garden and Dr. Eugene Jablonsky, who had treated a section of the Euphorbiaceae for the Pflanzenreich forty-five years ago! The area visited was the trail along the Mianus River on the New York-Connecticut line within 50 miles of the city. Here is a gorge with slopes that rise at some places to more than 200 feet. Here also are 300 year old hemlocks that crowd together in a particular spot and look very much like an outdoor cathedral.

Some notables among the various mushrooms we found were a cluster of *Collybia myriadophylla*, growing out of a hollow in the trunk of one of these huge standing hemlocks. These are violet-tinged little mushrooms with gills that are deep violet and amazingly crowded, limited to conifers, particularly hemlocks. Another mushroom we found growing on the ground was a creamy-white species of *Lyophyllum*, a genus partial to conifer woodlands, which has been seen in other places in our local area as well as at Mianus. The genus, not to be found in the standard manuals, was identified by Dr. Rogerson of the N. Y. Botanical Garden. It was proposed by Alexander Smith to accommodate certain species previously placed in *Tricholoma*, *Clitocybe* and *Collybia*, but distinguished by their smooth nonamyloid spores, and other features.

Some of the many ferns and fern allies seen were *Adiantum pedatum*, *Polypodium virginianum*, *Athyrium thelypteroides*, *Dryopteris marginalis*, *Osmunda regalis*, *Botrychium dissectum* var. *obliquum*, *Lycopodium clavatum*, *L. complanatum*, *L. lucidulum*, and *L. obscurum*.

The green fruited *Pilea pumila* and the black fruited *P. fontana* were growing together, also *Boehmeria cylindrica* and the stinging *Laportea canadensis*. Among the plants which had bloomed in the earlier season but were eye-catching in fruit now were *Allium tricoccum*, *Goodyera pubescens*, *Cimicifuga racemosa*, *Mitchella repens*, *Desmodium nudiflorum*, *D. cuspidatum*, *Amphicarpa bracteata*, *Lobelia inflata*, *Ilex verticillata*, *Polygonatum biflorum* and many more. Of the flowers in bloom nothing was as prominent as the goldenrods and asters, of which *A. linariifolius* can be mentioned, but we saw also *Gentiana Andrewsii* and spotted the ribbon-like flowers of the witch hazel just beginning to show. Leader, Eleanor Yarrow.

BOOK REVIEWS

Aquatic Phycomycetes, 2nd revised and enlarged ed. By Frederick K. Sparrow, Jr. 1–1187 pp. The University of Michigan Press, Ann Arbor. 22 July 1960. $22.50.

In 1943 the first edition of Aquatic Phycomycetes exclusive of the Saprolegniaceae and *Pythium* (785 pp.) by Dr. Sparrow appeared. It immediately became the standard work in the field and stimulated a great amount of study and research with these interesting organisms. It is apparent that not only the mycologists but algologists, limnologists, many botanists, biologists and zoologists also found the book indispensible to

their studies whether in teaching or in research. The book was soon much in demand and became out-of-print in a relatively short period for a scientific work.

Now Dr. Sparrow has brought out a completely revised and much expanded edition. Its publication is truly an achievement of great scientific merit. It is a scholarly presentation of all the microscopic phycomycetous fungi which occur in fresh and marine waters. In addition to the inclusion of species and genera of aquatic phycomycetous fungi described since the first edition, the revised volume has been extended to include descriptions of those species of *Pythium* (in key form) and *Phytophthora* that are known to exist in an aquatic habitat, to include genera of the Saprolegniaceae and citations of new taxa described since Coker (1923) and Coker and Matthews (1937), and to include the few desmid parasites belonging to the genus *Ancylistes* of the Entomorphthorales. Also added are the species of *Physoderma* parasitic on marsh and aquatic vascular plants as well as the species of Plasmodiophorales parasitic in aquatic cryptogams.

In the introduction (41 pp.) Dr. Sparrow discusses the aquatic phycomycetous fungi giving information on classification, phylogeny, the zoospore and its critical importance in these fungi, occurrence, hydrobiological aspects, distribution, collection, isolation and culture, and preservation. A conservative classification of the Phycomycetes into eleven orders which are grouped into three series (zoosporic-aquatic, zoosporic or "conidial"-mostly terrestrial, and conidial-terrestrial) has been maintained in the book. However, a footnote refers to Dr. Sparrow's more recent rearrangement (1959) of the Phycomycetes which he now considers to be an artificial group. A key to the ten orders with aquatic representatives ends the chapter.

The remainder and bulk of the volume consist of technical diagnoses of 10 orders, 24 families, 152 genera, and 781 species with 929 line illustrations. In the account of each order a summary is presented for taxonomic history, morphology and development, reproduction, cytology, features of biological interest, genetical data and references to pertinent physiological papers. Then follows the systematic account with descriptions and keys to families, genera and species, with additional information on substrata, collectors, bibliographic citation of collections, and localities by country.

The orders are arranged in the following "series" (not designated as subclasses): Uniflagellatae (Chytridiales 562 pp., Blastocladiales 92 pp., Monoblepharidales 47 pp., Hyphochytriales 25 pp.); Biflagellatae (Plasmodiophorales 24 pp., Saprolegniales 60 pp., Leptomitales 52 pp., Lagenidiales 198 pp., Peronosporales 49 pp.); conidial series (Entomophthorales 12 pp.). An index of substrata, a bibliography of over 1200 entries, and a general index complete the volume.

As indicated in the preface the date limit for the book was arbitrarily established as January 1, 1955. Those taxa published through 1957 have been inserted at the end of each genus. By use of numerous footnotes, references to new investigations, including some as recent as 1959, have been incorporated.

Perhaps the most controversial portion in the book is Dr. Sparow's placement of the Plasmodiophorales in the Phycomycetes. Several recent workers have considered the group to be a family of the Myxomycetes. The supporting evidence for the placement of members of the Plasmodiophorales in the Phycomycetes is presented although it is admitted that the whole group still urgently requires a thorough study.

Dr. Sparrow is to be congratulated and commended on the notable achievement of expanding and bringing up-to-date his account of the Aquatic Phycomycetes.—CLARK T. ROGERSON.

Drawings of British Plants. Part XIV. Adoxaceae-Dipsacaceae. By Stella Ross-Craig. *pl. 1–39.* Index. London: G. Bell & Sons Ltd. 21 Jul 1960. 10/6 [$1.48].

Among the 39 species illustrated in this part are *Viburnum opulus* and *V. lantana*, which occasionally escape in this country; thirteen species of *Galium* of which five circumboreal or introduced species are known here; *Linnaea borealis; Valeriana dioica* and *Valerianella olitoria;* and other species of interest to Americans. All are well illustrated

in enlarged detail: habit, flowers, fruit, cross section of stem, pubescence.—H. W. RICKETT.

Biological and Chemical Control of Plant and Animal Pests. Edited by L. P. Reitz. American Association for the Advancement of Science, Washington, D. C., 1960, xii + 273 pp.

This book is the result of a symposium presented by Section O on Agriculture at the annual meeting of the American Association for the Advancement of Science, December 28–30, 1957, in which the following topics were presented by the respective authors: I. The Public's Stake in Pest Control: 1. Exclusion and Eradication versus Reduction of Plant and Animal Pests, by M. R. Clarkson. 2. Control of Forest Diseases, by J. R. Hansbrough. 3. Control of Forest Insects, by James A. Beal. 4. Education in the Use of Pesticides, by E. H. Fisher. 5. Regulatory Control of Pesticides, by Bernard L. Oser.

II. Recent Advances in Chemical Control: 6. Fungicides and Bactericides for Controlling Plant Diseases, by George L. McNew. 7. Chemical Weed Control, by R. H. Beatty. 8. Organophosphorus Systemic Insecticides, by John E. Casida. 9. Chemical Control of Internal Parasites of Domestic Animals, by F. O. Gossett.

III. Biological Control of Pests: 10. Antagonism as a Plant Disease Control Principle, by William C. Snyder. 11. Pathogens for the Control of Pests, by John D. Briggs. 12. Nutrition of the Host and Reaction to Pests, by J. G. Rodriguez. 13. Control of Screwworm Fly by Atomic Radiation, by E. F. Knipling. 14. Parasites and Predators for Pest Control, by Charles A. Fleschner. 15. Effects of Disease and Insect Control Practices on Biological Balance in Apple Orchards, by A. D. Pickett. 16. Disease Resistance in Animals, by Nelson F. Waters. 17. Breeding Field Crops for Resistance to Diseases, by Ernest H. Stanford. 18. Breeding Vegetable and Fruit Crops for Resistance to Disease, by J. R. Shay, 19 Breeding Plants for Resistance to Insect Pests, by Reginald H. Painter.

This volume should be of interest to everyone concerned with plant and animal pests. Each article is presented by an outstanding scientist in the specific subject matter field. Each author has given an excellent summary of the subject and references to the literature. "Biological and Chemical Control of Plant and Animal Pests" should find excellent use as a reference for classroom work by both the student and the instructor and is a volume that every research and extension worker should have at his finger tips. BAILEY B. PEPPER, Agricultural Experiment Station, Rutgers—The State University, New Brunswick, New Jersey

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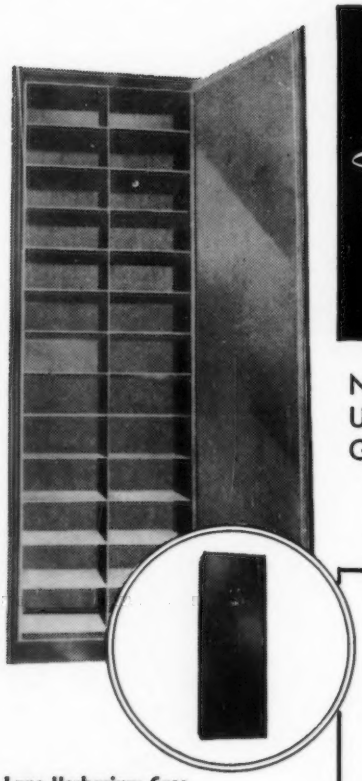

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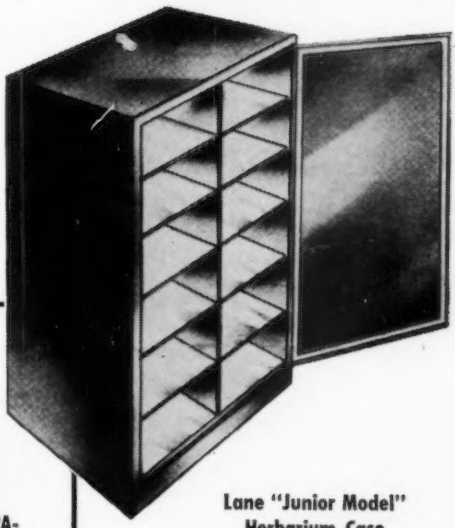

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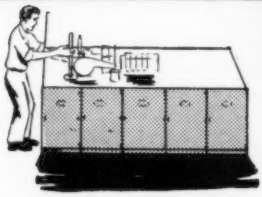

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ALGAE

Dixon, James R. Epizoophytic algae on some turtles of Texas and Mexico. Texas Jour. Sci. **12**: 36–38. Mai 1960.

Scott, Arthur W. & Prescott, Gerald W. Notes on Indonesian freshwater algae —IV. Concerning *Euastrum moebii* (Borge) Scott & Prescott comb. nov. and *Euastrum turgidum* Wallich. Reinwardtia **5**: 323–340. 21 Jul 1960.

Wallace, John H. New and variable diatoms. Not. Nat. **331**: 1–6. *pl. 1, 2.* 17 Jun 1960.

BRYOPHYTES

Miller, Harvey Alfred. Remarks on the succession of bryophytes on Hawaiian lava flows. Pacif. Sci. **14**: 246, 247. Jul 1960.

Persson, Herman & Sjörs, Hugo. Some bryophytes from the Hudson Bay lowland of Ontario. Sv. Bot. Tidskr. **54**: 247–268. 30 Jun 1960.

FUNGI

Baxter, John W. Notes on labiate rusts. Mycologia **51**: 598–601. Jul–Aug 1959 [4 Mai 1960].

Bigelow, Howard E. & Barr, Margaret E. Contributions to the fungus flora of northeastern North America. Rhodora **62**: 186–198. *pl. 1253.* 21 Jul 1960.

Capretti, Corrado. Notas técnicas de micologia: cultivo de hongos filamentosas en papel celofán y muestras para herbarios micológicos. Bol. Soc. Venez. Ci. Nat. **21**: 243–246. Jan 1960.

Chinn, S. H. F., Ledingham, R. J. & Sallans, B. J. Population and viability studies of *Helminthosporium sativum* in field soils. Canad. Jour. Bot. **38**: 533–539. 22 Jul 1960.

Farr, Marie L. *Stemonitis brasiliensis* and *Badhamia iowensis*—a correction. Mycologia **51**: 598. Jul–Aug 1959 [4 Mai 1960].

Gordon, W. L. The taxonomy and habitats of *Fusarium* species from tropical and temperate regions. Canad. Jour. Bot. **38**: 643–658. 22 Jul 1960.

Graham, Shirl O. The effects of various reagents, mounting media, and dyes on the teliospore walls of *Tilletia contraversa* Kühn. Mycologia **51**: 477–491. Jul–Aug 1959 [4 Mai 1960].

Hale, Mason E. The typification of *Parmelia cetrarioides.* Sv. Bot. Tidskr. **54**: 269–272. 30 Jun 1960.

Herrera, Teófilo. *Bovista* y *Scleroderma* en el Valle de México. Anal. Inst. Biol. México **30**: 35–37. 1959 [31 Mar 1960].

Hughes, S. J. Microfungi. V. *Conoplea* Pers. and *Exosporium* Link. Canad. Jour. Bot. **38**: 659–695. *pl. I–IV.* 22 Jul 1960.

Leppik, E. E. Some viewpoints on the phylogeny of rust fungi. III. Origin of grass rusts. Mycologia **51**: 512–528. Jul–Aug 1959 [4 Mai 1960].

Luck-Allen, E. Robena. The genus *Heterochaetella*. Canad. Jour. Bot. **38**: 559–569. 22 Jul 1960.

Raymond, F. L., Etchells, J. L., Bell, T. A. & Masley, P. M. Filamentous fungi from blossoms, ovaries, and fruit of pickling cucumbers. Mycologia **51**: 492–511. Jul–Aug 1959 [4 Mai 1960].

Singer, Rolf. New and interesting species of Basidiomycetes VII. Mycologia **51**: 578–594. Jul–Aug 1959 [4 Mai 1960].

Slysh, Anton R. The genus *Peniophora* in New York State and adjacent regions. St. Univ. Coll. Forestry Syracuse Univ. Tech. Bull. **83**: 1–95. *pl. 1*. 15 Jun 1960.

Snell, Walter H., Singer, Rolf & Dick, Esther A. Notes on boletes. XI. Mycologia **51**: 564–577. Jul–Aug 1959 [4 Mai 1960].

Thiers, Harry D. The agaric flora of Texas. III. New taxa of brown- and black-spored agarics. Mycologia **51**: 529–540. Jul–Aug 1959 [4 Mai 1960].

Thomas, G. P., Etheridge, D. E. & Paul, Glen. Fungi and decay in aspen and balsam poplar in the boreal forest region, Alberta. Canad. Jour. Bot. **38**: 459–466. 22 Jul 1960.

Wells, Kenneth. Studies of some Tremellaceae. III. The genus *Bourdotia*. Mycologia **51**: 541–563. Jul–Aug 1959 [4 Mai 1960].

PTERIDOPHYTES

Alta, Karen S. & Grant, Verne. Cytotaxonomic observations on the Goldback fern. Brittonia **12**: 153–170. 15 Jul 1960.

Brownlie, G. Studies on Pacific ferns, Part 1. Nomenclature changes and distributions of some species of *Hymenophyllum, Arthropteris, Microlepia, Oleandra,* and *Adiantum*. Pacif. Sci. **14**: 242–245. Jul 1960.

Legrand, Diego & Lombardo, Atilio. Flora del Uruguay. I. Pteridophyta. 1–67. Museo Nacional de Historia Natural. Montevideo. 1958.

Morton, C. V. Some fern books for different regions of the United States. Am. Fern Jour. **50**: 169–178. Apr–Jun 1960.

Rodin, Robert J. Ferns of the Sierra. Yosemite Nat. Notes **39**: 44–124. [1960.]

SPERMATOPHYTES

Anderson, Edward F. A revision of *Ariocarpus* (Cactaceae). 1. The status of the proposed genus *Roseo-cactus*. Am. Jour. Bot. **47**: 582–589. 18 Jul 1960.

Anon. Documented chromosome numbers of plants. Madroño **15**: 219–221. 13 Jul 1960.

Baker, Milo S. Studies in western violets, IX. Miscellaneous species in the sections *Nominium* and *Chamaemelanium*. Madroño **15**: 199–204. 13 Jul 1960.

Barkley, Theodore M. A revision of *Senecio integerrimus* Nuttall and allied species. Leafl. West. Bot. **9**: 97–113. 17 Aug 1960.

Beal, Ernest O. *Sparganium* (Sparganiaceae) in the southeastern United States. Brittonia **12**: 176–181. 15 Jul 1960.

Beaman, John H. Vascular plants on the cinder cone of Paricutin Volcano in 1958. Rhodora **62**: 175–186. 21 Jul 1960.

Birdsong, B. A., Alston, R. & Turner, B. L. Distribution of canavanine in the family Leguminosae as related to phyletic groupings. Canad. Jour. Bot. **38**: 499–505. 22 Jul 1960.

Boivin, B. & Löve, D. *Poa agassizensis*, a new prairie bluegrass. Nat. Canad. **87**: 173–180. Jun–Jul 1960.

Brade, A. C. Melastomatáceas novas do Estado de Santa Catarina (Melastomataceas novae IX). Sellowia **12**: 135–146. *pl. 1–6*. 15 Mai 1960.

Bravo, Helia. Una especies nueva de *Echinofossuclo-cactus* [*Mulliareolatus* sp. nov.]. Anal. Inst. Biol. México **30**: 59–61. 1959 [31 Mai 1960].

Brown, Walter V. Supernumerary chromosomes in a population of *Tradescantia edwardsiana*. Southw. Nat. **5**: 49–60. 10 Aug 1960.

Cody, W. J. Plants of the vicinity of Norman Wells Mackenzie District, Northwestern Territories. Canad. Field-Nat. **74**: 71–100. Apr–Jun [11 Jul] 1960.

Cowan, R. S. Rutaceae of Santa Catarina. Sellowia **12**: 79–97. *pl. 1–4*. 15 Mai 1960.

Cuatrecasas, José. Studies on Andean Compositae—IV. Brittonia **12**: 182–195. 15 Jul 1960.

Dressler, Robert L. The relationships of *Meiracyllium* (Orchidaceae). Brittonia **12**: 222–225. 15 Jul 1960.

Fell, Egbert W. The genus *Carex* in Rock River Valley in northern Illinois. 1–52. [Privately printed.] 1959.

Fosberg, F. R. *Serianthes* Benth. (Leguminosae–Mimosoideae–Ingeae). Reinwardtia **5**: 293–317. 21 Jul 1960.

Gerdemann, J. W. *Berberis pumila* on Iron Mountain, Oregon. Leafl. West. Bot. **9**: 116. 17 Aug 1960.

Gillett, George W. A systematic treatment of the *Phacelia Franklinii* group. Rhodora **62**: 205–222. Aug 1960.

Harris, Stuart K. *Sesbania exaltata* (Raf.) Cory in Essex County, Massachusetts. Rhodora **62**: 234. Aug 1960.

Howell, John Thomas. Subterranean clover in California and Oregon. Leafl. West. Bot. **9**: 114, 115. 17 Aug 1960.

Hunziker, Armando T. Catálogo de los tipos "Grisebachianos" conservados en Cordoba. Bol. Acad. Nac. Ci. Cordoba **41**: 283–421. Apr 1960.

Hunziker, Armando T. Estudios sobre Solanaceae. II. Sinopsis taxonómica del género *Dunalia* H.B.K. Bol. Acad. Nac. Ci. Córdoba **41**: 211–244. Apr 1960.

Iltis, Hugh H., Reed, Jack & Melchert, Thomas. *Elymus arenarius* and *Diarrhena americana* in Wisconsin. Rhodora **62**: 199–201. 21 Jul 1960.

Klein, Roberto M. O aspeto dinâmico de pinheiro brasileiro. Sellowia **12**: 17–44. *pl. 1–4*. 15 Mai 1960.

Kruckeberg, A. R. Chromosome numbers in *Silene* (Caryophyllaceae). II. Madroño **15**: 205–215. 13 Jul 1960.

Laverdière, Camille. Misa à jour de l'aire géographique de *Rhus radicans* var. *Rydbergii* dans le Québec. Bull. Serv. Biog. **21**: 53–68. 1959.

Legrand, C. Diego. *Calytranthes hatschbachii* sp. nov. Com. Bot. Mus. Hist. Nat. Montevideo **35**: 1–3. 31 Dec 1958.

Legrand, C. Diego. Comunidades Psamofilas de la region de Carrasco (Uruguay). Anal. Mus. Hist. Nat. Montevideo II. **6**: 1–53. *pl. 1–22*. Feb 1960.

Legrand, C. Diego. Desmembracion del genero *Portulaca*. Com. Bot. Mus. Hist. Nat. Montevideo **34**: 1–7. 31 Dec 1958.

Legrand, C. Diego. Dos nuevas especies Neotropicas de *Portulaca*. Com. Bot. Mus. Hist. Nat Montevideo **33**: 1–5. 31 Dec 1958.

Legrand, C. Diego. Las especies de los generos Caliptriformes del Brasil. Com. Bot. Mus. Hist. Nat. Montevideo **36**: 1–16. 31 Dec 1958.

Legrand, C. Diego. Las especies tropicales del genero *Gomidesia*. Com. Bot. Mus. Hist. Nat. Montevideo **37**: 1–30. 31 Dec 1958.

Legrand, C. Diego. Una nueva especie de *Portulaca* da Cordoba. Com. Bot. Mus. Hist. Nat. Montevideo **32**: 1–3. 31 Dec 1958.

Louis-Marie, *Père*. Cas d'introgession dans la flore du Québec. Revue Oka **34**: 1–11. 1960.

Macbride, J. Francis. Flora of Peru. Field Mus. Nat. Hist. Bot. Ser. **13** (Part 1 no. 2): 321–418. 17 Aug 1960.

Martínez, Maximino. Los encinos de México. XII. Anal. Inst. Biol. México **30**: 63–83. 1959 [31 Mar 1960].

Massey, A. B. The blessed thistle in Virginia. Rhodora **62**: 233, 234. Aug 1960.

Matuda, Eizi. Algunas especies nuevas de la flora mexicana. Anal. Inst. Biol. Mexico **30**: 101–115. 1959 [31 Mar 1960].

Matuda, Eizi. Las Juncaceas del Valle de Mexico y sus alrededores. Anal. Inst. Biol. Mexico **30**: 85–99. 1959 [31 Mar 1960].

Meyer, Frederick G. A new species of *Valeriana* [*glechomifolia*] from Brazil. Madroño **15**: 197–199. 13 Jul 1960.

Miranda, F. Posible significacion del porcentaje de generos bicontinentales en America tropical. Anal. Inst. Biol. Mexico **30**: 117–150. 1959 [31 Mar 1960].

Mohlenbrock, Robert H. & Drapalik, Donald J. *Eleocharis*, subseries *Palustres*, in Illinois. Am. Midl. Nat. **64**: 224–228. Jul [Aug] 1960.

Moss, E. H. Spring phenological records at Edmonton, Alberta. Canad. Field-Nat. **74**: 113–118. Apr–Jun [11 Jul] 1960.

Muhlenback, Viktor. Adventive plants new to the Missouri flora. Am. Midl. Nat. **64**: 161–168. Jul [Aug] 1960.

Ornduff, Robert. New or notable weeds from Oregon. Leafl. West. Bot. **9**: 113, 114. 17 Aug 1960.

Pergament, Eugene & Davis, R. L. Differentiation of red clover varieties. Agron. Jour. **52**: 258–261. 20 Mai 1960.

Rambo, B. Die europäischen Unkräuter in Südbrasilien. Sellowia **12**: 45–78. 15 Mai 1960.

Raven, Peter H. The correct name for rescue grass. Brittonia **12**: 219–221. 15 Jul 1960.

Raven, Peter H. *Rhagadiolus edulis* in California. Leafl. West. Bot. **9**: 116. 17 Aug 1960.

Raven, Peter H. & Mathias, Mildred E. *Sanicula deserticola*, an endemic of Baja California. Madroño **15**: 193–197. 13 Jul 1960.

Reitz, P. Raulino. Nictaginaceas catarienses. Sellowia **12**: 159–175. *pl. 1, 2.* 15 Mai 1960.

Riley, Herbert Parkes. Chromosome behaviour in *Tradescantia* triploid hybrids. Nucleus **2**: 1–8. 1959.

Riley, Herbert Parkes. Chromosome numbers in *Aloe*. Jour. S. Afr. Bot. **25**: 237–246. Jul 1959.

Riley, Herbert Parkes. Chromosome studies in *Gasteria* species and hybrids. Cytologia **24**: 438–446. 25 Dec 1959.

Riley, H. P. Chromosomes of some plants from the Kruger National Park. Jour. S. Afr. Bot. **26**: 37–44. Jan 1960.

Riley, Herbert Parkes & Hoff, Victor J. Spontaneous chromosome breakage in *Tulbaghia violacea*. Proc. 1st Cong. S. Afr. Genet. Soc. 57–60. 1959.

Rubtzoff, Peter. A record of *Eleocharis parvula* in the San Francisco Bay area. Leafl. West. Bot. **9**: 115. 17 Aug 1960.

St. John, Harold. Revision of the genus *Pandanus* Stickman. Part 1. Key to the sections. Pacif. Sci. **14**: 224–241. Jul 1960.

Sandwith, N. Y. *Ixora williamsii*. Rubiaceae. Bot. Mag. **173**: *pl. 352.* Apr 1960.

Sealy, J. Robert. *Petronymphe decora*. Liliaceae. Bot. Mag. **173**: *pl. 359.* Apr 1960.

Sealy, J. Robert. *Zygadenus fremontii.* Liliaceae. Bot. Mag. **173**: *pl. 361.* Apr 1960.

Sherff, Earl Edward. Some dicotyledonous plants recently collected in the Hawaiian Islands. Brittonia **12**: 170–175. 15 Jul 1960.

Smith, Lyman B. & Downs, Robert J. Resumo preliminar das amarantáceas de Santa Catarina. Sellowia **12**: 99–120. *pl. 1–8.* 15 Mai 1960.

Smith, Lyman B. & Downs, Robert J. Resumo preliminar das cariofiláceas de Santa Catarina. Sellowia **12**: 121–133. *pl. 1–6.* 15 Mai 1960.

Smith, Lyman B. & Downs, Robert J. Xyridáceas do herbario do Museu Paraense Emilio Goeldi. Bol. Mus. Emilio Goeldi II. Bot. **2**: 1–9. Aug 1959.

Steyermark, Julian A. Two new species of *Eleagia* (Rubiaceae) from South America. Bol. Soc. Venez. Ci. Nat. **21**: 240–242. Jun 1960.

Stoutamire, W. P. & Beaman, J. H. Chromosome studies of Mexican alpine plants. Brittonia **12**: 226–230. 15 Jul 1960.

Tateoka, Tuguo, Inoue, Sukemitsu & Kawano, Shigeko. Notes on some grasses. IX. Systematic significance of bicellular microhairs of leaf epidermis. Bot. Gaz. **121**: 80–91. Dec 1959 [27 Mai 1960].

Torres, A. M. A new species of *Zinnia* [*citrea*] from Mexico. Madroño **15**: 215–217. 13 Jul 1960.

Tucker, John M. & Haskell, Horace S. *Quercus Dunnii* and *Q. Chrysolepis* in Arizona. Brittonia **12**: 196–219. 15 Jul 1960.

Turner, B. L. & Fearing, Olin S. Chromosome numbers in the Leguminosae. III. Species of the southwestern United States and Mexico. Am. Jour. Bot. **47**: 603–608. 18 Jul 1960.

Woodson, Robert E., Schery, Robert W. *et al.* Flora of Panama. Part IV. fasc. 2. Ann. Missouri Bot. Gard. **47**: 81–203. Mai [5 Aug] 1960.

MORPHOLOGY

(including anatomy and cytology in part)

Atkinson, Lenette R. A new germination pattern for the Hymenophyllaceae. Phytomorphology **10**: 26–36. Mar [Jun] 1960.

Evert, Ray Franklin. Phloem structure in *Pyrus communis* L. and its seasonal changes. Univ. Calif. Publ. Bot. **32**: 127–194. *pl. 1–25.* 21 Apr 1960.

Forbes, Ian. A rapid enzyme-smear technique for the detection and study of plural embryo sacs in mature ovaries in several *Paspalum* species. Agron. Jour. **52**: 300, 301. 20 Mai 1960.

Gaudet, John. Ontogeny of the foliar sclereids in *Nymphaea odorata.* Am. Jour. Bot. **47**: 525–532. 18 Jul 1960.

Haber, Julia Moesel. The comparative anatomy and morphology of the flowers and inflorescences of the Proteaceae. I. Some Australian taxa. Phytomorphology **9**: 325–358. Dec 1959 [Mar 1960].

Hewitt, Florence Ellen. A morphological study of three South African Gigartinales. Univ. Calif. Publ. Bot. **32**: 195–234. *pl. 26–32.* 12 Mai 1960.

Hildebrand, E. M. Microrgy and the plant cell. Bot. Rev. **26**: 277–330. Jul–Sep 1960.

Johnston, George W. Abnormal pollen of *Tulipa.* Phytomorphology **9**: 320–325. Dec 1959 [Mar 1960].

Kuijt, Job. Morphological aspects of parasitism in the dwarf mistletoes (Arceuthobium). Univ. Calif. Publ. Bot. **30**: 337–436. *pl. 34–38.* 17 Mai 1960.

Lovett, James S. & Cantino, Edward C. The relation between biochemical and morphological differentiation in *Blastocladiella emersonii*, II. Nitrogen metabolism in synchronous cultures. Am. Jour Bot. **47**: 550–560. Jul 1960.

Nair, N. C. & Sukumaran, N. P. Floral morphology and embryology on *Brucea amarissima*. Bot. Gaz. **121**: 175–185. Mar [25 Jul] 1960.

Povilaitis, Bronius & Boyes, J. W. Ovule development in diploid red clover. Canad. Jour. Bot. **38**: 507–532. 22 Jul 1960.

Reines, M. & McAlpine, Robert G. The morphology of normal, callused, and rooted dwarf shoots of slash pine. Bot. Gaz. **121**: 118–124. Dec 1959 [27 Mai 1960].

Safijowska, Lubow D. Male gametophyte in *Enkianthus*. Bot. Gaz. **121**: 185–190. Mar [25 Jul] 1960.

Sastri, R. L. N. Vascularization of the carpel of *Myristica fragrans*. Bot. Gaz. **121**: 92–95. Dec 1959 [27 Mai 1960].

Sharman, B. C. Developmental anatomy of the stamen and carpel primordia in *Anthoxanthum odoratum*. Bot. Gaz. **121**: 192–198. Mar [25 Jul] 1960.

Sterling, Clarence & Pangborn, Jack. Fine structure of potato starch. Am. Jour. Bot. **47**: 577–582. 18 Jul 1960.

Sun, C. N. The effect of excising certain structures on foliar determination in *Arisaema consanguineum* Schott. Phytomorphology **10**: 37–42. Mar [Jun] 1960.

Sussex, Ian M. & Clutter, Mary E. A study of the effect of externally supplied sucrose on the morphology of excised fern leaves *in vitro*. Phytomorphology **10**: 87–99. Mar [Jun] 1960.

Weaver, Harry Lloyd. Vascularization of the root-hypocotyl-cotyledon axis of *Glycine max* (L.) Merrill. Phytomorphology **10**: 82–86. Mar [Jun] 1960.

GENETICS
(including cytogenetics)

Ashman, R. B. Stippled aleurone in maize. Genetics **45**: 19–34. Jan [20 Apr] 1960.

Bradley, S. G. Reciprocal crosses in *Streptomyces coelicolor*. Genetics **45**: 613–619. Mai [15 Jul] 1960.

Brewbaker, J. L. & Natarajan, A. T. Centric fragments and pollen-part mutation of incompatibility alleles in *Petunia*. Genetics **45**: 699–704. Jun [1 Aug] 1960.

Buckner, Robert C. Cross-compatibility of annual and perennial ryegrasses with tall fescue. Agron. Jour. **52**: 409, 410. 20 Jul 1960.

Day, P. R. The structure of the mating type locus in *Coprinus lagopus*. Genetics **45**: 641–650. Mai [15 Jul] 1960.

Dhillon, T. S. & Garber, E. D. The genus *Collinsia*. X. Aneuploidy in *C. heterophylla*. Bot. Gaz. **121**: 125–133. Mar [25 Jul] 1960.

Emmerling, M. H. The mutational behavior of the R^r: Jana allele in *Zea mays*. Genetics **45**: 763–769. Jun [1 Aug] 1960.

Everett, H. L. Effect of cytoplasms and an Rf gene in maize. Agron. Jour. **52**: 215, 216. 20 Apr 1960.

Flor, H. H. The inheritance of X-ray-induced mutations to virulence in a uredospore culture of race 1 of *Melampsora lini*. Phytopathology **50**: 603–605. 16 Aug 1960.

Fratello, Bernardo, Morpurgo, Giorgio & Sermonti, Guiseppe. Induced somatic segregation in *Aspergillus nidulans*. Genetics **45**: 785–800. Jun [1 Aug] 1960.

Goplen, B. P. & Stanford, E. H. Autotetraploidy and linkage in alfalfa—a study of resistance to two species of rootknot nematodes. Agron. Jour. **52**: 337–342. 20 Jun 1960.

Hashimoto, Kazuo. Streptomycin resistance in *Escherichia coli* analyzed by transduction. Genetics **45**: 49–62. Jan [20 Apr] 1960.

Kreizinger, Jean D. Diepoxybutane as a chemical mutagen in *Zea mays*. Genetics **45**: 143–154. Feb [5 Mai] 1960.

Lewis, C. F. & Richmond, T. R. The genetics of flowering response in cotton. II. Inheritance of flowering response in a *Gossypium barbadense* cross. Genetics **45**: 79–85. Jan [20 Apr] 1960.

McMichael, Scott C. Combined effects of glandless genes gl_2 and gl_3 on pigment glands in the cotton plant. Agron. Jour. **52**: 385, 386. 20 Jul 1960.

Maguire, Marjorie P. A study of homology between a terminal portion of *Zea* chromosome 2 and a segment derived from *Tripsacum*. Genetics **45**: 195–209. Feb [5 Mai] 1960.

Maguire, Marjorie P. A study of pachytene chromosome pairing in a corn-*Tripsacum* hybrid derivative. Genetics **45**: 651–664. Mai [15 Jul] 1960.

Mitchell, Mary B. Aseus formation and recombinant frequencies in *Neurospora crassa*. Genetics **45**: 507–517. Mai [15 Jul] 1960.

Neilsen, Etlar L. Cytology and fertility of small plants of *Bromus inermis*. Bot. Gaz. **121**: 133–139. Mar [25 Jul] 1960.

Ogur, M., Ogur, S. & St. John, R. Temperature dependence of the spontaneous mutation rate to respiration deficiency in *Saccharomyces*. Genetics **45**: 189–194. Feb [5 Mai] 1960.

Peterson, Peter A. The pale green mutable system in maize. Genetics **45**: 115–133. Jan [20 Apr] 1960.

Rhyne, Claude L. Leaf lobation in *Gossypium* amphidiploids as determined by leaf-shape genes of *Gossypium* diploid species. Genetics **45**: 63–78. Jan [20 Apr] 1960.

Rhyne, Claude L. Linkage studies in *Gossypium*. II. Altered recombination values in a linkage group of allotetraploid *G. hirsutum* L. as a result of transferred diploid species genes. Genetics **45**: 673–681. Jun [1 Aug] 1960.

Sadanaga, K. & Simons, M. D. Transfer of crown rust resistance of diploid and tetraploid species to hexaploid oats. Agron. Jour. **52**: 285–288. 20 Mai 1960.

Schaller, C. W., Holton, C. S. & Kendrick, E. L. Inheritance of the second factor for resistance to bunt, *Tilletia caries* and *T. foetida*, in the wheat variety Martin. Agron. Jour. **52**: 280–282. 20 Mai 1960.

Serres, Frederick J. de. Studies with purple adenine mutants in *Neurospora crassa*. IV. Lack of complementation between different ad-3A mutants in heterokaryons and pseudowild types. Genetics **45**: 555–566. Mai [15 Jul] 1960.

Somers, Carolyn E., Wagner, R. P. & Hsu, T. C. Mitosis in vegetative nuclei of *Neurospora crassa*. Genetics **45**: 801–810. Jun [1 Aug] 1960.

Soost, Robert K. Effects of gibberellic acid on genetic characters in two tomato lines. Bot. Gaz. **121**: 114–118. Dec 1959 [27 Mai 1960].

Suneson, Coit A. Genetic diversity—a protection against plant diseases and insects. Agron. Jour. **52**: 319–321. 20 Jun 1960.

Tuveson, R. W. & Garber, E. D. Genetics of phytopathogenic fungi. I. Virulence of biochemical mutants of *Fusarium oxysporum* f. *pisi*. Bot. Gaz. **121**: 69–74. II. The parasexual cycle in *Fusarium oxysporum* f. *pisi*. 74–80. Dec 1959 [27 Mai 1960].

Woodward, Dow O., Partridge, C. W. H. & Giles, N. H. Studies of adenylosuccinase in mutants and revertants of *Neurospora crassa*. Genetics **45:** 535–554. Mai [15 Jul] 1960.

PALEOBOTANY

Baxter, R. W. A first report of coal balls from the Pennsylvanian of New Brunswick, Canada. Canad. Jour. Bot. **38:** 697–699. 22 Jul 1960.

Baxter, Robert W. *Sporocarpon* and allied genera from the American Pennsylvanian. Phytomorphology **10:** 19–25. Mai [Jun] 1960.

Cahoon, Elizabeth J. *Sphenobaiera ikorfatensis* f. *papillata* from the Lakota formation of the Black Hills. Bull. Torrey Club **87:** 247–257. 16 Jul 1960.

Davis, Margaret B. A late-glacial pollen diagram from Taunton, Massachusetts. Bull. Torrey Club **87:** 258–270. 16 Jul 1960.

Radforth, N. W. & Terasmae, J. A palynological study relating to the Pleistocene Toronto formation. Canad. Jour. Bot. **38:** 571–580. 22 Jul 1960.

PHYTOPATHOLOGY

(See also under Genetics: **Flor; Tuveson & Garber; Sadanaga & Simons; Schaller et al.**)

Allen, Robert E., Vogel, O. A. & Johnston, C. O. Leaf rust resistance of semidwarf winter wheat selections, its inheritance and association with plant height. Agron. Jour. **52:** 408. 20 Jul 1960.

Arnold, B. C. Mycorrhizal infection of seedlings of *Nothofagus solandri* var. *cliffortioides* (Hook. f.) Poole. Pacif. Sci. **14:** 248–250. Jul 1960.

Arnold, W. N. & Bald, J. G. Turnip mosaic virus from two weed hosts. Phytopathology **50:** 578–581. 16 Aug 1960.

Asai, G. N. Intra- and inter-regional movement of uredospores of black stem rust in the upper Mississippi River valley. Phytopathology **50:** 535–541. Jul 1960.

Bald, J. G. & Goodchild, D. J. Tobacco mosaic virus in *Nicotiana glauca*. Phytopathology **50:** 497–499. Jul 1960.

Bald, J. G. & Solberg, R. A. Antagonism and synergism among organisms associated with scale tip rot of lilies. Phytopathology **50:** 615–620. 16 Aug 1960.

Beraha, Louis, Smith, M. A. & Wright, W. R. Gamma radiation dose response of some decay pathogens. Phytopathology **50:** 474–476. 23 Jun 1960.

Davey, C. B. & Papavizas, G. C. Effect of dry manure plant materials and nitrogen on *Rhizoctonia solani* in soil. Phytopathology **50:** 522–525. Jul 1960.

Dutta, S. K., Hall, C. V. & Heyne, E. G. Observations on the physiological races of *Colletotrichum lagenarium*. Bot. Gaz. **121:** 163–166. Mar [25 Jul] 1960.

Dutta, S. K., Hall, C. V. & Heyne, E. G. Pathogenicity of biochemical mutants of *Colletotrichum lagenarium*. Bot. Gaz. **121:** 166–170. Mar [25 Jul] 1960.

Fulton, Joseph P. Strawberry virus dissemination in Arkansas. Phytopathology **50:** 477–480. Jul 1960.

Fulton, Neil D. & Hanson, Earle W. Studies on root rots of red clover in Wisconsin. Phytopathology **50:** 541–550. Jul 1960.

Lockwood, John L. Pea introductions with partial resistance to *Aphanomyces* root rot. Phytopathology **50:** 621–624. 16 Aug 1960.

Milbrath, J. A. The epinasty virus reaction of Kwanzan and Shiro-fugen flowering cherry. Phytopathology **50:** 495–497. Jul 1960.

Murakishi, H. H., Honma, S. & Knutson, R. Inoculum production and seedling evaluation of celery for resistance to *Cercospora apii*. Phytopathology **50:** 605–607. 16 Aug 1960.

Ochs, Gertrud. Paper-chromatographic colorimeter method for expeditious diagnosis of leafroll virus of grapevines. Bot. Gaz. **121**: 198–200. Mar [25 Jul] 1960.

Ogawa, Joseph M. & English, Harley. Relative pathogenicity of two brown rot fungi, *Sclerotinia laxa* and *Sclerotinia fructicola*, on twigs and blossoms. Phytopathology **50**: 550–558. Jul 1960.

Papavizas, G. C. & Davey, C. B. *Rhizoctonia* disease of bean as affected by decomposing green plant materials and associated microfloras. Phytopathology **50**: 516–522. Jul 1960.

Powelson, R. L. Initiation of strawberry fruit rot caused by *Botrytis cinerea*. Phytopathology **50**: 491–494. Jul 1960.

Purdy, Laurence H. & Holton, C. S. Fungicide vapor action, ineffective in wheat smut control by seed treatment. Phytopathology **50**: 581–583. 16 Aug 1960.

Rangaswami, G. & Sambandam, C. D. Influence of substrate on spore size of *Alternaria melongenae*. Phytopathology **50**: 486–488. Jul 1960.

Smith, W. L. & McClure, T. T. *Rhizopus* rot of peaches as affected by post-harvest temperature and moisture. Phytopathology **50**: 558–562. Jul 1960.

Tamimi, S. A. & Dunn, G. M. Artificial inoculation of smooth bromegrass with *Pyrenophora bromi*. Agron. Jour. **52**: 238. 20 Apr 1960.

Trione, E. J. The HCN content of flax in relation to flax wilt resistance. Phytopathology **50**: 482–486. Jul 1960.

Wahl, I., Dinoor, A., Halperin, J. & Schreiter, S. The effect of *Rhamnus palaestina* on the origin and persistence of oat crown rust races. Phytopathology **50**: 562–567. Jul 1960.

Yerkes, William D. Interaction of potassium gibberellate and a stunting bean virus on beans, *Phaseolus vulgaris*. Phytopathology **50**: 525–527. Jul 1960.

PLANT PHYSIOLOGY

Andrews, J. E., Horricks, J. S. & Roberts, D. W. A. Interrelationships between plant age, root-rot infection, and cold hardiness in winter wheat. Canad. Jour. Bot. **38**: 601–611. Jul 1960.

Barnes, Robert L. & Naylor, Aubrey W. Studies on the ornithine cycle in roots and callus tissues of *Pinus serotina* and *Pinus clausa*. Bot. Gaz. **121**: 63–69. Dec 1959 [27 Mai 1960].

Bloom, James R. & Couch, Houston B. Influence of environment on diseases of turfgrasses. 1. Effect of nutrition, pH, and soil moisture on *Rhizoctonia* brown patch. Phytopathology **50**: 532–535. Jul 1960.

Converse, Richard H. Physiologic specialization of *Fusicladium effusum* and its evaluation in vitro. Phytopathology **50**: 527–531. Jul 1960.

Dedolph, Richard R. & Goto, Shosuke. The ripening response of bananas to some growth-regulator treatments. Bot. Gaz. **121**: 151–154. Mar [25 Jul] 1960.

Gorham, Eville & Gordon, Alan G. The influence of smelter fumes upon the chemical composition of lake waters near Sudbury, Ontario, and upon the surrounding vegetation. Canad. Jour. Bot. **38**: 477–487. Jul 1960.

Gottlieb, David, Carter, H. E., Wu, Lung-chi & Sloneker, J. H. Inhibition of fungi by filipin and its antagonism by sterols. Phytopathology **50**: 594–603. 16 Aug 1960.

Gowing, Donald P. & Leeper, Robert W. Studies on the relation of chemical structure to plant growth-regulator activity in the pineapple plant. I. Substituted phenyl and phenoxyalkylcarboxylic acids. Bot. Gaz. **121**: 143–151. Mar [25 Jul] 1960.

Johnson, S. P. A preliminary study of the effect of low concentrations of phenoxy-type growth regulators on early physiological shedding in Deltaphine, TPSA, cotton: II. Influence on flower initiation. Agron. Jour. **52**: 294, 295. 20 Mai 1960.

Linder, P. J. & Mitchell, J. W. Rapid transport of *a*-methoxyphenylacetic acid introduced directly into the water stream of bean plants. Bot. Gaz. **121**: 139–142. Mar [25 Jul] 1960.

Maier, Charles R. Streptomycin absorption, translocation, and retention in hops. Phytopathology **50**: 351–356. 17 Mai 1960.

Michel, Burlyn E. Indoleacetonitrile-indoleacetic acid synergism in the split pea test. Bot. Gaz. **121**: 95–105. Dec 1959 [27 Mai 1960].

Mooney, H. A. & Billings, W. D. The annual carbohydrate cycle of alpine plants as related to growth. Am. Jour. Bot. **47**: 594–598. 18 Jul 1960.

Mortimer, D. C. Iodoacetate inhibition of photosynthetic carbon dioxide assimilation in sugar beet and soybean leaves. Canad. Jour. Bot. **38**: 623–634. 22 Jul 1960.

Naguib, Kaiser & Saddik, Kamel. Growth and metabolism of *Aspergillus nidulans* Eidam on different nitrogen sources in synthetic media conducive to fat formation. Canad. Jour. Bot. **38**: 613–622. 22 Jul 1960.

Nitsch, J. P., Pratt, C., Nitsch, C. & Shaulis, N. J. Natural growth substances in Concord and Concord seedless grapes in relation to berry development. Am. Jour. Bot. **47**: 566–576. 18 Jul 1960.

Ormrod, D. P. & Williams, W. A. Vegetative and reproductive growth response of three *Trifolium* species to 2, 4-D. Agron. Jour. **52**: 229–234. 20 Apr 1960.

Randolph, L. F. & Khan, Reayat. Growth response of excised mature embryos of *Iris* and wheat to different culture media. Phytomorphology **10**: 43–49. Mar [Jun] 1960.

Roy, Chitra, Avadhani, P. N. & Towers, G. H. Induced synthesis of phlorin-C^{14} in *Pelargonium*. Canad. Jour. Bot. **38**: 489–498. 22 Jul 1960.

Samborski, D. J. & Forsyth, F. R. Inhibition of rust development on detached wheat leaves by metabolites, antimetabolites, and enzyme poisons. Canad. Jour. Bot. **38**: 467–476. 22 Jul 1960.

Schenk, Roy U. Source of the inner brown color of the peanut shell. Bot. Gaz. **121**: 191, 192. Mar [25 Jul] 1960.

Schooler, A. B. The effect of Gibrel and gibberellic acid (K salt) in embryo culture media for *Hordeum vulgare*. Agron. Jour. **52**: 411. 20 Jul 1960.

Sterling, Clarence & Kalb, A. J. Pectic changes in peach during ripening. Bot. Gaz. **121**: 111–113. Dec 1959 [27 Mai 1960].

Strider, D. L. & Winstead, N. N. Effect of temperature, pH, and various nutrients on growth of *Cladosporium cucumerinum*. Phytopathology **50**: 583–587. 16 Aug 1960.

Sussex, I. M., Clutter, Mary E., Lutinski, Jane B. & Dilks, Lois J. Extraction and biological properties of an antifungal fraction of woody plant tissues. Bot. Gaz. **121**: 171–175. Mar [25 Jul] 1960.

Trione, E. J. Extracellular enzyme and toxin production by *Fusarium oxysporum* f. *lini*. Phytopathology **50**: 480–482. Jul 1960.

Uden, N. van & Carmo-Sousa, Lidia do. Some physiological properties of *Geotrichum candidum*. Mycologia **51**: 595–598. Jul–Aug 1959 [4 Mai 1960].

Vaartaja, O. Effect of photoperiod on drought resistance of white spruce seedlings. Canad. Jour. Bot. **38**: 597–599. 22 Jul 1960.

Wang, Dalton. A study of the distribution of carbon-14 labelled compounds in stem rust infected wheat leaves. Canad. Jour. Bot. **38**: 635–642. 22 Jul 1960.

Ward, G. M. Sucrose synthesis in the seedling wheat leaf. Canad. Jour. Bot. **38**: 581–596. 22 Jul 1960.

Weaver, Robert J. & McCune, Stanley B. Further studies with gibberellin on *Vitis vinifera* grapes. Bot. Gaz. **121**: 155–162. Mar [25 Jul] 1960.

Wiegand, Oscar F. & Schrank, A. R. Regimen for growing uniform *Avena* coleoptiles. Bot. Gaz. **121**: 106–110. Dec 1959 [27 Mai 1960].

Wiggans, Samuel C. Responses of oat plants to various percentages of continuous shade. Bot. Gaz. **121**: 55–60. Sep 1959 [14 Mar 1960].

Wilson, Eugene M. Physiology of an isolate of *Fusarium oxysporum* f. *cubense*. Phytopathology **50**: 607–612. 16 Aug 1960.

Wu, Jia-Hsi, Hildebrandt, A. C. & Riker, A. J. Virus-host relationships in plant tissue culture. Phytopathology **50**: 587–594. 16 Aug 1960.

GENERAL BOTANY

(including biography and nomenclature)

Constance, Lincoln. Morton Eaton Peck (1871–1959). Taxon. **9**: 165–167. Jul–Aug 1960.

Fritz, Emanuel. Willis Linn Jepson, 1867–1946. Lover of California's trees and flowers. Jour. Calif. Hort. Soc. **9**: 23–26. Jan 1948.

Gilkey, Helen M. Morton Eaton Peck. Bull. Torrey Club **87**: 280–282. Aug 1960.

Jones, Keith. The lectotype species selections of Britton & Brown and the standard species of Hitchcock and Green. Taxon **9**: 175–191. Jul–Aug 1960.

Kral, Robert. Herbarium techniques. Rhodora **62**: 201, 203. *pl. 1254*. 21 Jul 1960.

Papazian, Haig. A simple, stationary, microdissecting needle. Bot. Gaz. **121**: 200. Mar [25 Jul] 1960.

Reeder, John R. Alexander William Evans (1868–1959). Taxon **9**: 168, 169. Jul–Aug 1960.

Reitz, P. Raulino. Homens ilustres e lugares catarinenses celebrados em nomes botânicos. Sellowia **12**: 147–157. 15 Mai 1960.